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NATIONAL INSTRUCTIONAL
MEDIA INSTITUTE, CHENNAI
ELECTRICIAN
SECTOR: Electrical
TRADE PRACTICAL
Post Box No. 3142, CTI Campus, Guindy, Chennai - 600 032
4th Semester
NSQF (LEVEL - 5)
DIRECTORATE GENERAL OF TRAINING
MINISTRY OF SKILL DEVELOPMENT & ENTREPRENEURSHIP
GOVERNMENT OF INDIA

(ii)
Sector : Electrical
Duration : 2 - Years
Trade : Electrician 4th Semester - Trade Practical - NSQF (LEVEL - 5)

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Entrepreneurship,
Government of India.
New Delhi - 110 001

General of Employment and Training (D.G.E & T), Ministry of Labour and Employment, (now under Ministry
of Skill Development and Entrepreneurship) Government of India, with technical assistance

from the Govt.
of the Federal Republic of Germany. The prime objective of this institute is to develop and provide instructional
materials for various trades as per the prescribed syllabi (NSQF) under the Craftsman and Apprenticeship
Training Schemes.
The instructional materials are created keeping in mind, the main objective of Vocational Training under
NCVT/NAC in India, which is to help an individual to master skills to do a job. The instructional materials
are generated in the form of Instructional Media Packages (IMPs). An IMP consists of Theory book,
Practical book, Test and Assignment book, Instructor Guide, Audio Visual Aid (Wall charts and
Transparencies) and other support materials.
The trade practical book consists of series of exercises to be completed by the trainees in the workshop.
These exercises are designed to ensure that all the skills in the prescribed syllabus are covered. The trade
theory book provides related theoretical knowledge required to enable the trainee to do a job. The test and
assignments will enable the instructor to give assignments for the evaluation of the performance of a
trainee. The wall charts and transparencies are unique, as they not only help the instructor to effectively
present a topic but also help him to assess the trainee's understanding. The instructor guide enables the
instructor to plan his schedule of instruction, plan the raw material requirements, day to day lessons and
demonstrations.
IMPs also deals with the complex skills required to be developed for effective team work. Necessary care
has also been taken to include important skill areas of allied trades as prescribed in the syllabus.
The availability of a complete Instructional Media Package in an institute helps both the trainer and
management to impart effective training.
The IMPs are the outcome of collective efforts of the staff members of NIMI and the members of the Media
Development Committees specially drawn from Public and Private sector industries, various training institutes
under the Directorate General of Training (DGT), Government and Private ITIs.
NIMI would like to take this opportunity to convey sincere thanks to the Directors of Employment &
Training of various State Governments, Training Departments of Industries both in the Public and Private
INTRODUCTION
This manual for trade practical is intended for use in the ITI workshop. It consists of a series

of practical exercises
that are to be completed by the trainees during the first semester of course is the Electrician trade under
Electrical Sector. It is National Skills Qualifications Framework NSQF (LEVEL - 5), supplemented and
supported by instructions/information to assist the trainees in performing the exercise. The exercises are designed
to ensure that all the skills prescribed in the syllabus are covered including the allied trades. The syllabus for the
4th Semester Electrician Trade under Electrical Sector Trade Practical is divided into Seven Modules. The
allocation of time for the various modules is given below:
Module 1 - Electronic Practice 15 Exercises 175 Hrs
Module 2 - Control Panel Wiring 5 Exercises 100 Hrs
Module 3 - AC/DC Motor Drives 3 Exercises 50 Hrs
Module 4 - Inverter and UPS 6 Exercises 75 Hrs
Module 5 - Power Generation and Substation 7 Exercises 50 Hrs
Module 6 - Transmission and Distribution 7 Exercises 50 Hrs
Module 7 - Circuit Breakers and Relays 5 Exercises 25 Hrs
Total 48 Exercises 525 Hrs
The syllabus and the content in the modules are interlinked. As the number of workstations available in the
electrical section is limited by the machinery and equipment, it is necessary to interpolate the exercises in the
modules to form a proper teaching and learning sequence. The sequence of instruction is given in the schedule
of instruction which is incorporated in the Instructor's Guide. With 25 practical hours a week of 5 working days
100 hours of practical per month is available.
Contents of Trade Practical
The procedure for working through the 48 exercises for the 4th semester with the specific objectives as the learning
out comes at the end of each exercise is given is this book.
The skill objectives tools/instruments, equipment/machines and materials required to perform the exercise are
given in the beginning of each exercise. Skill training in the shop floor is planned through a series of practical
exercises/experiments to support the related theory to make the trainees get hands on trainning in the Electrician
trade along with the relevant cognitive skills appropriate for the level. A minimum number of projects have been
included to make the training more effective and develop attitude to work in a team. Pictorial, schematic, wiring
and circuit diagrams have been included in the exercises, wherever necessary, to assist the trainees broaden their
views. The symbols used in the diagrams comply with the Bureau of Indian Standards (BIS) specifications.
Illustrations in this manual, help trainess visual perspective of the ideas and concepts. The

procedures to be
followed for completing the exercises are also given. Different forms of intermediate test questions have been
included in the exercises, to enhance the trainee to trainee and trainee to instructor interactions.
Skill Information
Skill areas which are repetitive in nature are given as separate skill information sheets. Skills which are to be
developed in specific areas are included in the exercises itself. Some sub exercises are developed to fulfill the
sequence of exercises in keeping with the syllabus.
This manual on trade practical forms part of the Written Instructional Material (WIM), which includes manual on
trade theory and assignment/test.

CONTENTS

CONTENTS
Exercise No. Title of the Exercise Page No.

ASSESSABLE / LEARNING OUTCOME
On completion of this book you shall be able to
• Detect the faults and troubleshoot inver
Plan, assemble and install a solar panel
• Erect an overhead domestic service line and outline various power plant layout.
• Examine the faults and carryout repairing of circuit breakers.
• Identify the control and functional switches in a C.R.O and measure the DC and AC voltage, frequency time period.

• Construct and test a half and fullwave rectifiers with and without filter circuits.
• Draw and wire up the control panel for forward/ reverse operation of an induction motor.
• Control speed and reverse the direction of rotation of different type of three phase induction motor using VVVF control /AC drive

ELECTRICIAN 4TH SEMESTER SYLLABUS
Fourth Semester Duration: Six Month

Week No.	Learning outcome Reference	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
	• Assemble simple electronic circuits and test for functioning.	160. Determine the value of resistance by colour code and identify types. (10 Hrs) 161. Test active and passive electronic components and its applications. (15 Hrs)	79 Resistors - colour code, types and characteristics. Active and passive components. Atomic structure and semiconductor theory.
80-81	• Assemble simple electronic circuits and test for functioning.	162. Determine V-I characteristics of semiconductor diode. (10 Hrs) 163. Construct half wave, full wave and bridge rectifiers using semiconductor diode. (10 Hrs) 164.Check transistors for their functioning by identifying its type and terminals. (10 Hrs) 165. Bias the transistor and determine its characteristics. (10 Hrs) 166. Use transistor as an electronic switch and series voltage regulator. (10 Hrs)	P-N junction, classification, specifications, biasing and characteristics of diodes. Rectifier circuit - half wave, full wave,

bridge rectifiers and filters.
Principle of operation, types, characteristics and various configuration of transistor.
Application of transistor as a switch, voltage regulator and amplifier.
82-83 • Assemble simple Electronic circuits and test for functioning.
167. Operate and set the required frequency using function generator. (12 Hrs)
168. Make a printed circuit board for power supply. (10 Hrs)
169. Construct simple circuits containing UJT for triggering and FET as an amplifier. (12 Hrs)
170. Troubleshoot defects in simple power supplies. (16 Hrs)
Basic concept of power electronics devices.
IC voltage regulators
Digital Electronics - Binary numbers, logic gates and combinational circuits.
84-85 • Assemble simple electronic circuits and test for functioning.
171. Construct power control circuit by SCR, Diac, Triac and IGBT. (15 Hrs)
172. Construct variable DC stabilized power supply using IC. (10 Hrs)
173. Practice on various logics by use of logic gates and circuits. (15 Hrs)
174. Generate and demonstrate wave shapes for voltage and current of rectifier, single stage amplifier and oscillator using CRO. (10 Hrs)
Working principle and uses of oscilloscope.
Construction and working of SCR, DIAC, TRIAC and IGBT.
Principle, types and applications of various multivibrators.
86-87 • Assemble accessories and carry out wiring of control cabinets and equipment.
175. Design layout of control cabinet, assemble control elements and wiring accessories for:
(i) Local and remote control of

induction motor. (15 Hrs)
(ii) Forward and reverse operation of induction motor. (10 Hrs)
Study and understand Layout drawing of control cabinet, power and control circuits.
Various control elements: Isolators, pushbuttons, switches, indicators, MCB, fuses, relays, timers and limit switches etc.

ELECTRICIAN 4TH SEMESTER SYLLABUS
Fourth Semester Duration: Six Month

Week No.	Learning outcome Reference	Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
88-89	• Assemble accessories and carry out wiring of control cabinets and equipment.	176. Carry out wiring of control cabinet as per wiring diagram, bunching of XLPE cables, channeling, tying and checking etc. (15 Hrs) 177. Mount various control elements e.g. circuit breakers, relays, contactors and timers etc. (10 Hrs) 178. Identify and install required measuring instruments and sensors in control panel. (10 Hrs) 179. Test the control panel for its performance. (15 Hrs)	Wiring accessories: Race ways/ cable channel, DIN rail, terminal connectors, thimbles, lugs, ferrules, cable binding strap, buttons, cable ties, sleeves, gromats and clips etc. Testing of various control elements and circuits.
90-91	• Perform speed control of AC		

and DC motors
by using solid
state devices.
180. Perform speed control of DC motor using thyristors / DC drive. (18 Hrs)
181. Perform speed control and reversing the direction of rotation of AC motors by using thyristors / AC drive. (18 Hrs)
182. Construct and test a universal motor speed controller using SCR. (14 Hrs)
Working, parameters and applications of AC / DC drive.
Speed control of 3 phase induction motor by using VVVF/AC Drive.
92-94 • Detect the faults
and troubleshoot
inverter, stabilizer,
battery charger,
emergency light
and UPS etc.
183. Assemble circuits of voltage stabilizer and UPS. (15Hrs)
184. Prepare an emergency light. (10 Hrs)
185. Assemble circuits of battery charger and inverter. (15 Hrs)
186. Test, analyze defects and repair voltage stabilizer, emergency light and UPS. (15 Hrs)
187. Maintain, service and troubleshoot battery charger and inverter. (10 Hrs)
188. Install an Inverter with battery and connect it in domestic wiring for operation. (10 Hrs)
Basic concept, block diagram and working of voltage stabilizer, battery charger, emergency light, inverter and UPS.
Preventive and breakdown maintenance.
95 • Erect overhead
domestic service
line and outline
various power
plant layout.
189. Draw layout of thermal power plant and identify function of different layout elements. (5 Hrs)
190. Draw layout of hydel power plant and identify functions of different layout elements. (5 Hrs)
Conventional and nonconventional sources of energy and their comparison.

Power generation by thermal and hydel power plants.

ELECTRICIAN 4TH SEMESTER SYLLABUS
Fourth Semester Duration: Six Month

Week No.	Learning outcome	Reference Professional Skills (Trade Practical) With Indicative Hours	Professional Knowledge (Trade Theory)
		191. Visit to transmission / distribution substation. (10 Hrs) 192. Draw actual circuit diagram of substation visited and indicate various components. (5 Hrs)	
96	• Plan, assemble and install solar panel. • Erect overhead domestic service line and outline various power plant layout.	193. Prepare layout plan and Identify different elements of solar power system. (05 Hrs) 194. Prepare layout plan and Identify different elements of wind power system. (05 Hrs) 195. Assemble and connect solar panel for illumination. (15 Hrs)	Various ways of electrical power generation by non-conventional methods. Power generation by solar and wind energy. Principle and operation of solar panel.
97	• Erect overhead domestic service line and outline various power plant layout.	196. Practice installation of insulators used in HT/LT line for a given voltage range. (5 hrs) 197. Draw single line diagram of transmission and distribution system. (5 Hrs) 198. Measure current carrying capacity of conductor for given power supply. (5 hrs)	

199. Fasten jumper in pin, shackle and suspension type insulators.
(10 Hrs)
Transmission and distribution networks.
Line insulators, overhead poles and method of joining aluminum conductors.
98 • Erect overhead domestic service line and outline various power plant layout.
200. Erect an overhead service line pole for single phase 230 V distribution system in open space. (10 Hrs)
201. Practice on laying of domestic service line. (10 Hrs)
202. Install bus bar and bus coupler on LT line. (5 Hrs)
Safety precautions and IE rules pertaining to domestic service connections.
Various substations.
Various terms like - maximum demand, average demand, load factor, diversity factor, plant utility factor etc.
99 • Examine the faults and carry out repairing of circuit breakers.
203. Identify various parts of relay and ascertain the operation. (5 Hrs)
204. Practice setting of pick up current and time setting multiplier for relay operation. (5 hrs)
205. Identify the parts of circuit breaker, check its operation. (5Hrs)
206. Test tripping characteristic of circuit breaker for over current and short circuit current. (5 hrs)
207. Practice on repair and maintenance of circuit breaker.
(5 hrs)
Types of relays and its operation.
Types of circuit breakers, their applications and functioning.
Production of arc and quenching.

ELECTRICIAN 4TH SEMESTER SYLLABUS
Fourth Semester Duration: Six Month
Week
No.
Learning outcome
Reference

Professional Skills
(Trade Practical)
With Indicative Hours
Professional Knowledge
(Trade Theory)
100-101 Project work / Industrial visit
Broad Areas:
a) Battery charger/Emergency light
b) Control of motor pump with tank level
c) DC voltage converter using SCRs
d) Logic control circuits using relays
e) Alarm/indicator circuits using sensors
102-103 Re

Electrical Exercise 4.1.160
Electrician - Electronic Practice
Determine the value of resistance by colour code and identify the types
Objectives: At the end of this exercise you shall be able to
• identify the types of resistors by referring to the pictorial representation
• identify the colour bands, and decode the resistance value
• calculate the tolerance value by the colour band
• measure the actual value with an ohmmeter verify with calculated value.

Requirements

Tools/Instruments
• Multimeter/Ohmmeter - 1 No.
Materials
• Various types of resistors (assorted values) including potentiometers of carbon track and wire-wound type. - as reqd

PROCEDURE
TASK 1: Identify the type of resistor from pictorial representation
1 Identify the resistor’s type by referring Fig 1 and write the type in Table 1.
2 Sketch the I.S. symbol for the identified resistor i

TASK 2 : Identify the colour band and decode the resistance value
1 Identify the value of resistors shown in Fig 2 from the colour bands and enter Table 2.
2 Identify the first two colour bands of the resistors given by the instructor (in sequence commencing from the 1st colour band closer to one end of the resistor - Refer Fig 3.
3 Write the 1st number and 2nd number in Table 2.
4 Identify the colour of the 3rd band and write the multiplier value in the respective column in Table 2.
5 Compute the value of the resistor and record in

Table 2.
6 Identify the 4th band colour and fill up the tolerance in Table 2.
7 Determine the resistance value and the tolerance for the another given resistors and record in Table 3 by repeating the above steps 1 to 6.
8 Measure the value of the resistors by using a multimeter/ohmmeter and enter the values in Table 3 by following the procedure given below.

Sl.No.	Colour	1	2	3	4	Multiplie	Resistance value	Temperature

Connect the probes
i Connect the red probe to the POSITIVE terminal
ii Connect the black probe to the COMMON terminal
b Set the multimeter/ohmmeter (Fig 4)
i Set the range selector switch to one of the ohm range.
c Conduct zero ohm adjustment in analog multimeter
i Short-circuit the two probes at the selected range.
ii Turn the ohm adjustment knob until the pointer is set at zero ohm. (zero adjustment)
d Connect the resistor to be measured.
i Keep your finger tips off from the probes.
ii Maintain firm contact with the resistor lead wires.
e Read the meter
i Use a range which deflects the pointer to middle of the scale (Fig 5)

iv In Fig 4, the resistance range x 100 is selected, if so the value of the resistance is 15 x 100 = 1500 ohms = 1.5 (K Ohm)
9 Enter the marked value of resistance and tolerance

(by the colour band over the resistor) in Table 3.
10 Calculate the minimum and maximum values of actual resistance for each resistor considering the tolerance marked over it. (Table 3) Record the values in Table 3.
11 Determine the acceptability (OK or not OK) by comparing the measured value with the minimum and maximum of the indicated value.
Note : Each range selection zero adjustment is to be ensured for correct value of resistance.
Table 3

Sl.No.	Band 1st Band	Band 2nd Band	Band 3rd Band	Band 4th Band	Recorded value in Ohm	Tolerance value of resistance %	Max. value of resistance	Min. value of resistance	Measured value of resistance	Remarks OK or not OK
1										
2										
3										
4										
5										
6										
7										
8										
9										
10										

12 Report and get it checked by your instructor.
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.1.160
ii Read the meter in the Ohm scale right above the pointer. (In this case 15 as shown in Fig 5)
iii Resistance = (Ohm scale reading) x (Magnification at selected range of the resistance range).

Electrical Exercise 4.1.161

Electrician - Electronic Practice

Test active and passive electronic components and its applications

Objectives: At the end of this exercise you shall be able to

• identify the electronic components - diode, diode bridge, transistor, SCR, IC by referring to the pictorial representation

• identify the given electronic components- diode, diode bridge, selenium bridge, transistor, IC, by visual inspection

• read the symbols for active components in the given circuit diagram

• identify the active components and their base diagram, lead configuration by referring to the data book by component code number

• decode and name the semi conductor devices - diodes transistors, SCRs

• identify the passive components by visual inspection

• interpret the coding and marking on the components

• test the components for its working conditions.

Requirements

Tools/Instruments
• Multimeters/Ohmmeter - 1 No.
Materials/Components
• Capacitors, inductors, resistors
(assorted size, shape and values) - as reqd.
• Assorted components of diodes,
transistors, SCRs, DIACs, TRIACs, UJTs,
FETs bridge diodes etc of different
types with semi-conductor data manual - as req

TASK 1: Identify the active components
Assumption: Given components have their
code number, lead identification marks are
available in data book
1 Look at the Fig 1. Identify the component from the pictorial representation. Give your response in Table 1.
2 Write the figure Nos. that indicate the components given in Fig 2, in Table 2
Table 1
Sl.No. Figure number Component's name
1 Fig 1 a
2 Fig 1 b
3 Fig 1 c
4 Fig 1 d
5 Fig 1 e
Table 2
Sl. No. Figure number Component's name
1 Transistor with heat sink
2 Diode bridge
3 Integrated circuit
4 Diode
5 Transistor
3 Match the names and pictorial representations of the active components (Fig 3).Record your response in the space provided.
4 Collect the electronic (ACTIVE) components from your instructor. Identify the components and record your response in your record book along with sketches of the components. (Refer Fig 3 for guidance)

Table 3
Sl. No. Labels Components Component's
names symbol

1 A
2 B
3 C
4 D
5 E
6 F
7 G
8 H
9 I
10 J

Table 4

Sl. No.	Code No. of Component's components	name
1	OA79	
2	DR25	
3	IN4007	
4	AA119	
5	BY127	
6	BZ148	
7	BC147	
8	2N904	
9	BD115	
10	BFW10	
11	3N187	
12	BTY87	
13	2N2646	
14	D3202Y	
15	T2801B	
16	CA741	
17	CA723	
18	NE555	

Table 5

Sl.No.	Code No.	Base diagram
1	IN4007	
2	SL100	
3	BC147	
4	2N5296	
5	2N3035	
6	SN204	
7	2N2646	
8	3N187	

TASK 2 : Identify and check the passive components

Instructor shall select the resistors, inductors and capacitors so that, few can be visually identified and other can be identified by coding only.

1 Identify the passive components referring to Fig 1 and write the type of passive component in Table 1.

2 Sketch the appropriate symbol against the corresponding type of passive components in Table 1.
3 Get your result corrected by your instructor.
4 Collect assorted size, shape and type of passive components from your instructor.
5 Divide the passive components into separate groups as resistor, inductor and capacitor by their appearances (or) code references.
6 Interpret, the code references of resistor and list them in Table 2.
7 Measure the value of resistance of each by multimeter and record in Table 2.
8 Interpret the code references of capacitor and list them in Table 3.
9 Check the capacitor for charge and discharge by multimeter, and record the condition in Table 3 by referring Fig 7lectrical Exercise 4.1.162
Electrician - Electronic Practice
Determine the V-I characteristics of semi conductor diode
Objectives: At the end of this exercise you shall be able to
• refer data book and
a) identify the diode is Ge, Si etc
b) verify operating voltage and current rating
c) list the application of the diode
• identify the terminals of a diode and test the diode for its condition
• plot the forward characteristics, determine the forward resistance of the diode and the barrier potential
• plot the reverse characteristics of the diode

Requirements

Tools/Instruments
• Multimeter (Digital) - 1 No.
• Voltmeter MC 0-1 V - 1 No.
• Milliammeter MC 0-25 mA - 1 No.
• Voltmeter MC 0-30 V - 1 No.
• Micro ammeter MC 0-100 Micro Amp - 1 No.
• Semi conductor diode data book - 1 No.
Equipment/Machines
• DC regulated power supply
0- 30 V, 1 A - 1 No.
Materials
• Assorted types of diodes including
IN 4001 or IN 4007 - as reqd.
• 570 Ω, 5W potentiometer - 1 No.
• SPST switch 6A 250V - 1 No.
• Bread board 150 x 150 mm - 1 No.
• Suitable connecting wires for
bread board - as reqd.

• Patch cords with clips - 2 sets
• 100Ω 1/4 W resistor - 1 No.
• 10 Ω 1/4 W resistor

PROCEDURE

TASK 1: Refer the diode with data book

1 Select any one of the given assorted diodes. Record the type number printed on the diode in the Table 1.

2 Refer diode data book and search for the type number of the selected diode.

3 In data book check for the column which indicates Material or mat. against the referred diode. Record the type of semiconductor used following the tips given below:

– Under the column material or mat,

– if code S or Si is printed it means the material used for making the diode is silicon.

– if code G or Ge - Germanium

– if code Se - Selenium

4 Look in the data book for the column which indicates Rated peak reverse voltage abbreviated as VR or Vr or PIV against the referred diode. Find and record the indicated value of rated peak reverse voltage in Table 1.

5 Get as done in step 4 and record the following specifications of the referred diode from the data book:

- IF of If - Maximum average forward current
- VF of Vf - Forward voltage drop at specified IF
- Is - Maximum forward surge current
- IVT - Maximum reverse current at VR
- Function - Normal use/application of the diode.

The coding used for Function differs from data book to data book. Consult instructor in case of difficulty.

6 Repeat steps 1 to 5 for atleast ten different types of given diodes.

7 Refer diode data book or diode equivalents data book and identify one or two equivalent diode types for each diode. For those diodes you collected the specification.

8 Get your work checked by your instructor. Sl. Type Material Rated Max. Max. Forward Max. Application Equivalent No. No.of peak reverse average voltage forward diode type diode reverse current IV forward current VF surge volta

ASK 2 : Identify the terminal leads of a given diode

1 Set the multimeter in ohms range (W x 1). Connect its leads to a M.C. voltmeter (0-3V), to find out the polarity of multimeter output voltage.

In digital multimeter the marked polarity and polarity of output voltage are the same.

2 Check the deflection of the voltmeter, if it indicates the voltage, mark the terminal of the multimeter corresponding to the voltmeter polarity

3 Mark the terminal of the multimeter opposite to voltmeter polarity. If the voltmeter kicks back then.

4 Connect the +ve marked terminal for the multimeter to one terminal of the diode and other to the -ve and observe the reading.

a) If the meter reads low resistance then the lead of the diode connected to +ve marked terminal of the meter is the ANODE and the other is cathode.

(Fig 1a)

b) If the meter does not deflect as in Fig 1b then the lead of the diode connected to +ve marked terminal for the multimeter is the cathode and the other is anode.

If the meter reads low resistance for both polarities the diode is short.

If the meter reads high resistance for both polarities the diode is open.

TASK 3 : Determine the forward V-I characteristic of the diode

1 Construct the circuit in the bread board as in Fig 2.

2 Set initially VB = 0 and switch ON the power supply.

3 Set VB= 5V, set the potentiometer to minimum position.

4 Close the switch S and adjust potentiometer to increase the voltage across the diode in steps of 0.1 V as per the Table.1

5 Record the corresponding values of current read by the ammeter in the Table.1.

Table 1

VF Volt	0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0	2.0
IFmA	0											

6 Check the value of voltage across the diode at which the current starts increasing and remain constant at later.

7 Switch OFF the supply

8 Plot the graph with VF on X axis and IF on Y- axis.

9 Determine the forward resistance.

ohms

V

R

F

F

F I

=

From the graph determine the knee point voltage at which large quantity of current starts flowing. Enter the value below.

Knee point voltage .... volts If the knee point voltage is around 0.3 V or 0.7V the diode is germanium or silicon respectively.

Note : Increase the voltage beyond 2.0V as indicated in case diode is not reached in saturation current.

TASK 4 : Determine the reverse V-I characteristic of a diode

1 Construct the circuit in a bread board as in Fig 3. (Reverse the Diode terminals with respect to previous task)

2 Switch on the power supply and close the switch S.

3 Increase the voltage gradually across the diode by operating the power supply as per Table 2 and note down the corresponding current read by the ammeter in Table 2.

4 Switch OFF the power supply.

5 Plot the graph on the same graph sheet (Task 3) with VR on x-axis and IR on Y-axis.

6 Determine the minority carrier current from the graph.

If the reverse voltage becomes equal to the PIV of the diode then the diode starts conducting and not to increase the voltage beyond PIV of the diode.

7 Repeat the experiment for different type of diodes.

Table 2

VR Volts	0	5	10	15	20	30

Electrical Exercise 4.1.163
Electrician - Electronic Practice
Construct half-wave, full wave and bridge rectifiers using semi conductor diode
Objectives: At the end of this exercise you shall be able to
• construct a half-wave rectifier and test
• construct and test a full-wave rectifiers using two diodes
• construct and test bridge type, full wave rectifiers using four diodes.
Requirements
Tools/Instruments
• Trainees kit - 1 No.
• Soldering iron 25W/250V - 1 No.
• Voltmeter MC 0-30V - 1 No.
• Multimeter (Digital) - 1 No.
Materials/Components
• Lug board General purpose 5 points - 1 No.
• Diode IN4007 - 4 Nos.
• Resistor 470Ω (Ohm) - 1 No.
• Step-down transformer,
240V/12.0.12, 500mA - 1 No.
• Multi strand wire, red, blue 23/0.2
of 650V grade - as reqd.
• Base board - 1 No.
(Laminated board 30x15x3mm)
• Mains cord 3 core cable
23/0.2 of 650V grade - 1 No.
• Nuts, bolts and washers - as reqd.
• 3 Pin plug 6A 250 V - 1 No.
• Resin core solder 60/40 - as reqd.
PROCEDURE
TASK 1: Construct half-wave rectifier and test it
1 Test the continuity of the primary and secondary windings of the given transformer. Record the specifications of the given transformer.
2 Follow the order of steps given below by referring Fig 1.
• Mount the tested transformer as shown in Fig 1 on BASE BOARD using suitable size nuts, washers and bolts. Get it checked by your instructor.
• Mount the rectifier diode on lug board by soldering
• Solder the wire connection and the three core power cord. (Fig 1a & Fig 1b)
3 Connect AC mains to the board and switch ON mains.

Measure and record the mains voltage and transformer secondary voltage VS(rms) (AC input to rectifier) in the Table 1.
4 Calculate and record the calculatedVdc = 0.45 VS(rms) where, VS(rms) is the AC input to the rectifier.
5 Measure and record the rectified DC voltage Vdc across load RL using multimeter.
6 Record the difference in the calculated and measured values.
7 Get it checked by your instructor.
Transformer specifications
Rated primary voltage
Rated secondary voltage
Secondary current or VA rating of transformer
Type of transformer step-up/ step down
No. of windings in seTASK 2 : Construct fullwave rectifier with centre tap transformer
1 Check to confirm good condition of the given components. Record specifications of the transformer.
2 Construct a full wave rectifier circuit as shown in the schematic and layout diagram at Fig 2a & Fig 2b.
Transformer specifications
1 Rated primary voltage ------
2 Rated secondary voltage between centre tape and one end ------
3 Rated secondary current or VA rating transformer ------
3 Switch ON the circuit. Measure the AC input voltage Vs(rms) to the rectifier across the center-tap and any one end of the transformer and record it in Table 2.
4 Calculate the expected DC voltage Vdc across load R L using the formula given below;
In full wave rectifier, V dc = 0.9 Vs(RMS) where, Vs(rms) is the voltage across the centre-tap and any one end terminal of secondary. Record the value in Table 2.
5 Measure the rectified output Vdc across load RL and record it Table 2.

6 Calculate and record the difference in the calculated and measured Vdc values. Get it checked by your instructor.
Table 2
Readings of two-diode full-wave rectifier

Vs(rms) Calculated Measured Difference of Peak value of V s Frequency of Vs
Vdc volts Vdc volts (2) & (3)
(1) (2) (3) (4) (5) (6)
TASK 3 : Construct bridge rectifier
1 Modify the two diode full wave rectifier wired in Task 2 to construct a bridge rectifier, referring to the schematic and layout diagrams (Fig 3a & Fig 3b).
2 Switch On the circuit. Measure and record the AC input Vs(rms) to the rectifier in Table 3.
3 Calculate the expected output DC voltage Vdc across load RL using the formula, In a bridge rectifier.
Vdc = 0.9 Vs(rms) where, V s(rms) is the AC input to the rectifier (refer Fig 3). Record the value in Table 3.
Table 3
Readings of bridge rectifier
Vs(rms) Calculated Measured Difference of Peak value of V s Frequency of Vs
Vdc volts Vdc volts (2) & (3)
(1) (2) (3) (4) (5) (6)

4 Measure the DC output V dc across the load R L and record it in Table 3.
5 Record the difference in the calculated and measured values in Table 3.
6 Report and get it checked by your instructor.

Electrical Exercise 4.1.164
Electrician - Electronic Practice
Check transistors for their functioning by identifying its type and terminals
Objectives: At the end of this exercise you shall be able to
• identify a transistor from its type-number the following information referring to a data book;
a) silicon or germanium
b) PNP or NPN
c) package type
d) base, emitter, collector pins.
• test the condition of a given transistor using ohmmeter/multimeter.
Requirements
Tools/Instruments
• Trainees kit - 1 No.
• International transistors data book - 1 No.
• Ohmmeter/multimeter - 1 No.
Materials/Components

• Assorted type of transistors - 10 Nos
• Sleeve wires of red, yellow, blue
and black colours 1mm dia - as reqd.

PROCEDURE

TASK 1 : Identify transistor type and leads, referring to data manual

1 Take any one transistor from the given assorted lot (Fig 1), enter its label number and transistor type number in Table 1.

2 Refer to transistor data manual, find and record the following details of the transistor in Table 1

• Whether silicon or germanium
• Whether NPN or PNP
• Type of packaging or case outline (Example: TO5, TO7 etc.)

Table 1 (With sample data)

Label No.	Transistor type No.	Semi- Conductor /type	Type of package	Pin Diagram	E- B Junction resistance in forward bias (E-B & B-C)	B-C resistance in reverse bias
Sample	BC107	Si/NPN	T018		Low	Very High

3 From the type of package recorded, refer to the transistor data manual and draw the pin diagram indicating base, emitter and collector for the transistor in Table 1.

4 Put sleeves of suitable length (Fig 1) to the identified pins of the transistor using the colour scheme given below:

Base : Blue colour sleeve
Emitter : Red colour sleeve
Collector : Yellow colour sleeve
Shield : Black colour sleeve

In power transistors, the metal body itself will be the collector. In such cases, mark ‘C’ on the metal body using a pencil. All transistors will not have shield pin.

5 Repeat steps 1 to 4 for atleast five transistors of different types in the given lot and get your work checked by your instructor.

TASK 2 : Check the transistor for PNP or NPN type

Referring a data book with respect to transistor number gives the information whether transistor is PNP or NPN. In the absence of data book this test will be useful.

1 Ascertain the +ve and -ve polarity of the ohmmeter leads.

2 Hook the negative lead of the ohmmeter test prod to

the base and the positive lead of the ohmmeter tASK 3 : Test transistor for its working condition

1 Identify which terminal of the ohmmeter being used is connected to the +ve terminal of the internal battery of the meter. Set the meter range to RX100Ω.

Ohmmeters in very low or very high ohms range can produce excessive current/voltage and may damage low power transistors while testing.

2 Take a transistor whose pins are identified and sleeved at Task 1. Depending on whether the chosen transistor is NPN or PNP, clip/hold the +ve or -ve of the meter prod to the base of the transistor as shown in Fig 4a and 4b.

3 Clip the other meter prod to the emitter. Check if the base-emitter junction diode of transistor shows low resistance (few tens of ohms) or very high resistance (few tens of kiloohms). Record your observation in Table 3.

4 Reverse the polarity of the prod connected across the base-emitter and check if the base-emitter junction diode of transistor shows low resistance or very high resistance. Record your observation in Table 3.

5 From the recorded observations in steps 3 and 4, and referring to the table given below, conclude and record, the condition of the base-emitter junction diode of the transistor as GOOD, open or shorted in Table 3.

If the resistance of the junction measured in both directions is high, in addition to the condition of the junction given in table, an other possibility is, your identified base pin may be wrong. You may be measuring resistance across emitter-collector. In case of doubt, recheck the identified pins of the transistor and repeat steps 2,3 and 4.

6 Repeat steps 2,3,4, and 5 and check the condition of the base-collector junction diode of the transistor.

7 Measure the resistance across the emitter-collector and record the observation as V-HIGH (> 1MΩ) or LOW (<500Ω).

In a good transistor the resistance between the emitter and collector will be very high. A low resistance indicates that the transistor is leaky.

8 Clip the meter across the emitter-collector with correct

polarity as in Fig 5. Touch the base-collector with moist finger as in Fig 5 and check if the resistance shown by the meter decreases indicating that the transistor is turning ON. Record your observation as YES or NO in Table 3.

9 From the observations recorded at steps 5,6,7 and 8, give your conclusion on the overall condition of the transistor under test. Refer Table 3.

10 Repeat the steps 1 to 9 for atleast five more transistors of different types.

11 Report and get your work checked by your instructor.

Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.1.164

Table 3

Resistance of P - N junction with meter prods in one direction	Resistance of P - N junction with meter in reversed direction	Condition of P - N Junction
Low	Very High	Good
Low	Low	Shorted
Very High	Very High	Open (see Note above)

Electrical Exercise 4.1.165

Electrician - Electronic Practice

Bias the transistor and determine its characteristics

Objectives: At the end of this exercise you shall be able to

• wire up and test a fixed-bias transistor amplifier
• wire up and test a emitter-bias transistor amplifier
• wire and test a voltage divider-bias transistor amplifier
• draw characteristics curve with respect to base current with collector current in all conditions.

Requirements

Tools/Equipments/Instruments

• Trainees kit - 1 No.
• DC millammeter, 0 - 1 mA - 1 No.
• DC millammeter, 0- 100 mA - 1 No.
• Regulated power supply, 12V, 1A - 1 No.

Materials/Components

• SL100 or equivalent metal can - 2 Nos.
transistors
• Tag board code no.110-03-TB - 1 No.
• Resistors, Carbon, 1/4 W
120 Ω - 1 No.
470 Ω - 1 No.
1K Ω - 2 Nos
5.6K Ω - 1 No.
182K Ω - 1 No.
330K Ω - 1 No.

PROCEDURE

TASK 1: Wire up and test fixed bias transistor amplifier

1 Construct the circuit (Fig 1) on the tag board. Identify the type of biasing used in Fig 1 and record in Table 1 Use the transistor having low βββββ value, (around 100)

2 Switch ON 12V, DC supply to the circuit. Measure and record values of IB, IC, VBE and VCE in Table 1. The readings taken are at normal room temperature.

3 Hold the heated barrel of the soldering iron close to the transistor (but not touching) for 30 sec to 1 min and observe the change in the collector current. Record the changed value of IB, IC, VBE and VCE at elevated temperature of the transistor. The transistor is heated to observe the effect of heat on the set Q point of the transistor.

Table 1

Fixed bias transistor amplifier

Description	IB µA	IC mA	VBE volt	VCE volt
Reading taken at room temperature				
Readings taken at elevated tempUse transistor as an electronic switch and series voltage regulator				

Objectives: At the end of this exercise you shall be able to

• determine the minimum forward bias current required to switch the transistor from OFF to ON condition

• construct transistorised series voltage regulator and test

• measure ripple at input and out put of the regulator and find ripple factor

ools/Instruments

• Ammeter MC - (0-100 milliamp) - 1 No.

• Ammeter MC (0-100 microamp) - 1 No.

• Voltmeter MC (0-15 V) - 1 No.

• Trainees Kit

• Unregulated DC power supply

0-30VDC/1A - 1 No.

CRO, 20 MHz - 1 No./ batch

Equipment/Machines

• DC regulated power supply;

0-30 V 1amp - 1 No.

Materials

• Transistor BC 107 - 1 No.

• Lamp 6V, 150 mA - 1 No.

• Variable resistor 250K 1 W - 1 No.

• Bread board - 1 No.

• Connecting leads - as reqd.

• Dry cell 1.5 V - 1 No.

- Tag board (Code no. 111-01-TB) -1 No.
- Transistor SL 100 or equivalent - 1 No.
- Zener diode, 12V, 1/4W - 1 No.

180Ω - 1 No.
1KΩ - 2 Nos.
220 Ω - 1 No.
330 Ω - 1 No.

- Capacitor, 10µF, 25V - 1 No.
- LED, Red colour - 1 No.
- Hook up wires (Red and Black) each - 1 Meter
- Rosin core solder

PROCEDURE

TASK 1: Perform the using of the transistor as an electronic switch

1 Collect the specifications from the data book for the transistor used in the circuit diagram. (Fig 1)

2 Form the circuit as per the given circuit diagram (Fig 1)

Check for the specific range of instruments and correct polarity.

Keep the supply OFF and the voltage knob of power supply unit at 0V.

3 Switch ON the power and set the collector supply to 10V by operating the voltage knob.

4 Switch ON the battery supply by closing the switch S1 to the base-emitter circuit.

5 Adjust VR for base current of 5 microamps and note the collector current and record it in Table 1.

6 Change Ib to 90 microamps insteps as in the Table 1.

Table 1

Base current in micro-ampere 5 10 20 30 40 50 60 70 80 90

Collector current in milliampere

State

7 Check the value of Ib for which I c has not changed, (i.e. Ic is saturated).

8 Vary the Ib base current between the two readings to find the exact value of Ib at which Ic reaches saturation.

9 Set the Ib to a value just above minimum to cause Ic saturation and check for ‘ON’ ‘OFF’ action by operating switch S1. Switch OFF power supply.

10 Connect a lamp 6V, 150mA in the collector circuit as

in Fig 1 and switch ‘ON’ the power supply.
11 Check lamp glowing; if not slightly adjust the base current to increase till the lamp ‘ON’.
12 Confirm the lamp operation by operating base current of Transistor.
13 Draw the base to the collector current graph, and mark the states of the transistor. (Fig 2)

TASK 2 :Construct transistorised series voltage regulator

1 Refer data book and record the required details of the given transistor in Table 2.

Table 2

Sl.No.	Input P.S voltage in volts	O/P P.S voltage in volts	Remarks
1	6		
2	8		
3	10		
4	12		
5	14		
6	16		

2 Test to confirm the condition of the given components.
3 Solder the components on the given Tag board as per the schematic diagram and layout shown in Fig 3 and 4 respectively. Get the wired circuit checked by your instructor.
4 Connect an unregulated DC voltage of 0 - 30V to the input terminals of the wired series regulator board.
5 Get the interconnections made checked by your instructor.
6 Switch on the AC mains supply to the unregulated dc supply.
7 Measure and record the input voltage and output voltage of the series regulator.
8 Measure and record the following voltage levels in observation and tabulation sheet .
a) Voltage across zener, VZ
b) VCE of the transistor Q1
c) VBE of the transistor Q1.
9 Keep input P.S Voltage 2V and measure O/P voltage and record in Table 2.
10 Increase the voltage steps of two and record the corresponding O/P voltage in Table 2.
11 Increase the voltage steps up to 16V and record. Beyond 12V in the output voltage, any increase in input voltage beyond 12V, 14V or 16V will not make any change in output voltage.
12 Switch 'OFF' & Connect to the CRO to the I/P side and O/P side of P.S. (using dual trace CRO) measure and record the ripple presentation the circuit. Record it in Table 2.

13 Calculate the ripple factor in Table 2.

Ripple factor in %
- Calculated _____
- Original _____

Electrical Exercise 4.1.167
Electrician - Electronic Practice
Operate and set the required frequency using function generator
Objectives : At the end of this exercise you shall be able to
• identify the various controls of the function generator
• operate the equipment and set the required frequency and wave form
• measure the time and frequency of the set waveform using CRO.
Requirements
Tools/Instruments
• 10 MHz oscilloscope dual Trace - 1 No.
• Function generator - 1 No.
• AF oscillator 20 kHz - 1 No.
Materials
• Patch cords - 1 Set.
PROCEDURE
TASK 1: Practice using of a function generator
1 Locate the various control of the function generator on its front panel which may look like Fig 1. (Some other model have few changes)
2 Keep the amplitude adjustment knob to a minimum position.
3 Connect B & C cable to CRO and set CRO working/ measuring conditions.
4 Using patch cords connect the output terminals of the function generator to the input terminals of the CRO. Keep both the instruments in OFF position.
5 Press the function switch to select sine wave.
6 Select 10 Kilo Hertz Range by pressing the range switch marked ‘X 10 K’
7 Keep the fine frequency dial to position 2 (Fig 1).
8 Set AC-DC switch to AC position (out) in the CRO.
9 Switch ‘ON’ the power of both function generator and the CRO. Adjust the trace to be on the centre of the screen.
10 Adjust the amplitude knob of the function generator and the Volts/DIV on the CRO To get a clear sine wave on the screen follow the illustration (Fig 2).

11 Adjust the TIME/DIVISION knob to get adequate number of peaks on the screen.
Relationship between TIME/DIV. (sweep time) and No. of peaks.
When the TIME/DIV. switch is turned clockwise, the time per one period of saw-tooth wave will become small and the wave-form part is stretched. (Fig 3)
12 Adjust the X-shift control to move the start of the measurement period to a convenient reference point (intersecting point of vertical and horizontal lines). (Fig 4)
13 Check the time period of the wave form. The time between a and b can be determined by counting the no. of horizontal divisions and multiplying it with time base range.
Example
If the time base is set to 0.01 millisecond. There are 5 divisions between ‘a’ and ‘b’.
therefore time period t = 5 x 0.01 = 0.05 ms
therefore frequency of the wave form
‘f’ t
1
= = 3-
100.05
1
×
= 20 kHz.
14 Vary the frequency range settings on the functions generator (follow the Table.1) and verify the output frequency using oscilloscope.
15 Set the function switch to some other wave (e.g. square, triangular etc.,) and repeat the steps 9 to 13 (Note to record the readings in Table 1). Only sine wave entry is needed in Table 1.
Table 1

Trial No.	Range switch position	Fine freq. dial position	Set frequency	Measured frequency using CRO	Remarks
1	x 1	10	10 Hz	—-	
2	x 10	5	50 Hz	—-	
3	x 100	3.5	350 Hz	—-	
4	x 1K	5	5 kHz	—-	
5	x 10K	0.1	1 kHz	—-	
6	x 100K	2	200 kHz	—-	

TASK 2 : Practice using a AF oscillator
Most of the AF oscillators produce sine wave only. In certain AF oscillator, there will be a

provision for square wave in addition to sine
wave.
1 Follow the procedure out lined in Task 1 to measure
the output frequency of a AF generator (oscillator) and
enter the reading in Table 2 for the given settings.
Table 2

Trial No.	Range switch position	Fine frequency dial position	Set frequency	Measured frequency using CRO	Remarks
1	x 10	1	10 Hz	—-	
2	x 10	5	50 Hz	—-	
3	x 100	3.5	350 Hz	—-	
4	x 1K	5	5 kHz	—-	
5	x 10K	0.1	1 kHz	—-	
6	x 100K	2	200 kHz	—-	

Electrical Exercise 4.1.168
Electrician - Electronic Practice
Make a printed circuit board for power supply
Objectives: At the end of this exercise you shall be able to
• transfer the layout on to a copper clad board
• punch component mounting holes
• paint the pattern using etch-resist ink pen, Indian ink or enamel paint
• etch a painted copper clad board
• trace the component side pattern and make the components
• drill holes on the PCB
• rivet tags/terminals at input and output points.
Requirements
Tools/Equipments/Instruments
• Centre punch, sharp tip - 1 No./batch
• Wooden mallet - 1 No./batch
• Trainee’s Kit - 1 No./each
• Hand drill/Push-type drill gun - 1 No./batch
• Drill bit, 0.8 m - 1 No./batch
• Drill bit, 2 mm - 1 No./batch
• Bench vice/Table vice - 1 No./batch
• Wooden block (of PCB size) - 1 No./batch
• Glass rod, 30 cm long - 1 No./batch
Materials/Components
• Detergent soap powder - 10 gms.
• White cotton cloth - 1/4 mt.
• Carbon paper, A4 size - 1 No.
• Adhesive tape - as reqd.
• Etch-resist ink pen, black or Indian - 1 No.
ink & fine brush No.6
• Copper clad, 1 oz, 75 x 60 mm - 1 No.

(Phenolic) single side
• Copper clad board - as reqd.
• FeCl3 in liquid or powder form - 50 ml.
• Detergent soap powder - 10 gm.
• Thinner/Alcohol/Petrol - 100 ml.
• Post-type termination tags,
riveting type - 4 Nos.
• Turret type termination tags,
riveting type - 2 Nos.
• Carbon paper, A4 size - 1 No.
• Plastic tray, 30 cm x 15 cm aprox. - 1 No.
• Plastic hand gloves - 1 pair
• Glass rod, 30 cm - 1 No.
• Plastic table spoon, 10 ml - 1 No.
• Painting brush, fine, No. 6 - 1 No.
• Permanent marker, blue, fine tip - 1 No.
PROCEDURE
TASK 1: Prepare the tracks on copper clad board
1 Clean the copper side of the 75 mm x 60 mm single side copper clad board using soap and water. Dry it using a piece of cloth.
Presence of oil or dust on the clad hinders transferring of the layout on the board.
2 Take a fresh carbon paper of 85 x 70mm and fix it on the copper clad board. (Fig 1)
3 Take out the PCB circuit pattern diagram of power supply, prepared for making power supply.
4 Fix the circuit pattern over the carbon paper (fixed on the copper clad board at step-2) as in Fig 2. Get it checked by your instructor.
Use adhesive tapes at several places such that the layout drawing sheet does not slip off while tracing.

5 Make punch marks using a centre punch, at the centres of all inner circles and thedentify the internal polarity of the terminals of the ohmmeter/multimeter and insert the red probe to the meter terminal connected to +ve of internal battery and black probe to -ve of the internal battery by referring Chart 1.
7 Set the meter to Rx1000 range. Refer table given below and test the given JFET. Record the readings taken for each JFET in Table 3.
Chart 1
Measured Resistance
GATE SOURCE DRAIN GOOD FET BAD FET

1 OPEN - Ve + Ve Very Low High/VH
2 OPEN + Ve - Ve Very Low High/VH
3 - Ve OPEN + Ve Very High Low/VL
4 + Ve OPEN - Ve Very Low High
5 - Ve + Ve OPEN High Low
6 + Ve - Ve OPEN Low High

8 From the recorded resistance readings in Table 3, give your conclusion on the condition of the JFET. (Refer Table 2)
9 Repeat the steps 2 and 3 for the remaining N-channel JFET's.
10 Get the work checked by your instructor.
Table 3

FET No.	Gate	Source	Drain	Measured resistance	Condition good/bad
	open	-ve	+ve		
	open	+ve	-ve		
	-ve	open	+ve		
	+ve	open	-ve		
	-ve	+ve	open		
	+ve	-ve	open		

TASK 3 : Construct and test an AC/FET amplifier and plot the graph
1 Refer Fig 2 and construct an AC voltage amplifier using a N-channel FET.
Construct the circuit on a bread board or on a GPCB. If you are wiring the circuit on a GPCB use base for the FET to ensure that it does not get damaged.
2 Get the wired circuit checked by your instructor.
3 Power ON wired circuit. Feed input, at 10 kHz and level from 1mV to 1V in steps of 100mV. Measure the corresponding output levels by using CRO and record in Table 4.
4 From the recorded readings at step 3, calculate and record gain of the amplifier.
5 Get the recorded readings checked by your instructor.
6 Calculate the gain of the amplifier with an input of 400 mV at frequencies 40 KHz, 80 KHz, 100 KHz, 120 KHz and at 150 KHz in Table 5.
7 Get the work checked by your instructor.
voltageInput
voltageOutput
Table 4
Input frequency : 10 KHZ

Sl.	Input	Output	Gain =

No. voltage voltage
1 100 mV
2 200 mV
3 300 mV
4 400 mV
5 500 mV
6 600 mV
7 700 mV
8 800 mV
9 900 mV
10 1V
Table 5
Input volt
Frequency Gain =
kHz
40
80
100
120
150
8 Plot the graph input/output voltage vs gain as in the
first case and frequency vs gain in the second case.
9 Get the graph approved by instructor.
voltageInput
voltageOutput

Electrical Exercise 4.1.170
Electrician - Electronic Practice
Troubleshoot defects in simple power supplies
Objectives: At the end of this exercise you shall be able to
• carry out step-by-step troubleshooting of a power supply having bridge rectifier and capacitor filter
• carry out a short cut method of troubleshooting of the power supply through problem tree and service flow
diagram.
Requirements
Tools/Equipments/Instruments
• Trainees kit - 1 No.
Materials/Components
• Bridge rectifier power supply
circuit with filter - 1 No.
• Spare components - as reqd.
PROCEDURE
TASK 1 : Troubleshoot defects in bridge rectifier power supply
1 In the given power supply board, refer Fig 1. Check

for any one of the physical defects listed below;
Record the observed defect(s) in Table 1. Service the defect(s).
– Loose/open wire connections.
– Loose/open component lead connections.
– Dry solder points.
– Shorting of terminals due to solder spray or bad skinning/bending of wire ends or component leads.
2 Trace the circuit wiring and check the correctness of the following.
– Polarity of diodes
– Polarity of polarized capacitors.
Correct the polarities if found defective and record the defect observed and polarity corrected in Table 1.
3 Open one of the wire ends of the power cord connected to the power supply. (Fig 2)
This will disconnect the transformer primary from the power cord.
4 Using a continuity tester, check the power cord for any one of the following defects and record the defect observed if any;
– Open or shorted wires in the plug.
– Open or shorted wires in the 2-core cable.
5 Check the continuity of transformer primary winding. If found open or short the coils record defect.
6 Remove the wires soldered at the secondary winding terminals of the transformer (Fig 3).Check the continuity of the secondary windings. Record your observation.
7 Open one lead of each diode (Fig 4). Check the condition of the diodes. Record your observation in Table 1.

Table 1

Sl.No.	Name of the defective component to be replaced	Nature of defect observed	Specification of the component to be replaced	Equivalents, Specification of the components to to be replaced
Sample	Solderred point	Dry solder	.....	..... De-soldered

8 Open one of the leads of the capacitor. Check the condition of the filter capacitor by carrying out the capacitor action test. Record your observation in Table 1.
9 Check the condition of the bleeder/load resistor. Get the defects recorded in steps above, checked by your instructor. Get his approval to replace the

components found defective.
11 Collect and test the new components to replace the identified defective components.
12 Replace the defective components with the new components and solder back all connections opened while testing.
13 Connect serviced power supply to AC mains and switch ON mains supply. Check and record the output condition in Table 2 under the heading final condition after servicing.
If there is no output from the PSU even after carrying out the laid procedure of servicing, consult your instructor.
The output may have problems other than the one for which it is serviced. Record the problem as it is observed.
14 Get the work checked by your instructor.
Final condition of power supply after servicing
a) Output voltage level
b) Ripple voltage Vr(p-p) in output DC
TASK 2 : Troubleshoot defects in power supply using shortcut/logical approach method
1 Switch 'ON' the given defective power supply unit and record the identified defect in record sheet.
2 Refer the problem tree corresponding to the identified defect.
3 Refer the service flow sequence (SFS-1) or (SFS-2) depending on the identified defect of power supply. Follow the logical sequence to service the defective power supply.
4 Record the identified component defects and remedial measure taken in Table 2 of record sheet.
Refer the problem tree corresponding to the SFS for finding the possible causes of the defects.
Whenever any component is found defective, record its type, cause of defect and other details in the Table 2 of record sheet.
Whenever any component is replaced, record the specification of the replaced component in Table 2 of the record sheet.
Once the servicing as per SFS is complete, record the final condition of the power supply in Table 2 as done in step 13 of Task 1.
5 Get your work checked by your instructor.
6 Final condition of power supply after servicing.
a) Output voltage level :
b) Ripple voltage Vr(p-p) in output DC :
7 Refer service flow chart 1 & 2 and follow the sequence

of approach.
8 Interpret the problem Tree-Chart 1 & 2 (PTC-1 &
PTC -2) and locate the exact fault / repair.
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Service flow Sequence (SFS-1)
NATURE OF DEFECT : Low output DC
Carry out physical defect checkings and correct the defects found
Carry out component polarity, trace, check and correct the defects found
Filter
capacitor
OK
?
Are
diod

Practice on various logics by use of logic gates and circuits
Objectives: At the end of this exercise you shall be able to
• construct an OR gate using lamp and switches and verify its truth table
• construct an OR gate using IC-7432 and verify its truth table
• construct AND gate using lamps and switches
• construct AND gate using IC-7408
• construct NOT gate and verify truth table using transistor

Requirement

Tools/Equipments/Instruments/Materials
• Trainees kit - 1 No.
• Regulated DC power supply unit
5V/500mA - 1 No.
• DC voltmeter (MC) 0-10V/multimeter - 1 No.
• Data Manual - 1 No.
• Digital IC tester - 1 No.
Materials/Components
• Single pole switch any type/
Toggle switch 240V/6A - 2 Nos.
• Lamp - 250V/100W - 1 No.
• LED, Red (5mm) - 2 Nos.
• ICs
7408 QUAD AND gate - 1 No.
7432 - 1 No.
• Connecting wires - as reqd.
• Solder, flux - as reqd.
• IC base, 14 pin - 2 Nos.

• DC power supply 5V - 1 No.
• SPDT switches - 2 Nos.
(miniature toggle)
• General purpose IC - 1 No.
test board/Pin Board
• Transistor BC 147 - 1 No.
• Resistors, carbon film, 1/4w
1KW - 2 Nos.
330W - 2 Nos.
• LED (t5mm)
Green - 2 Nos.
• IC 7404 (Hex inverter) - 1 No.
• IC 4049 (Hex inverter) - 1 No.
• IC base 14-pin - 2 Nos.
• Hookup wire
Red 50cm - as reqd.
Black 50 as reqd.cm

PROCEDURE
TASK 1: Construct an OR gate using two switches with lamp and verify its truth table
1 Refer Fig 1 and wire an OR gate circuit on a test board/pin board. 2 Apply logic level inputs to A and B of the circuit as given in Table 1. Record the output lamp condition in each case and verify its truth table.
3 Get the recorded readings checked by your instructor.
Table 1
Truth table of OR-gate using switches and lamp
Logic input Logic output
A SW1 B SW2 Y = A + B lamp
0 0
0 1
1 0
1 1
Construct a Quad two input OR gate using IC-7432
1 Record the details of the given IC-7432 in Table 2 of record sheet referring to data manual.
2 Insert the IC-7432 into the IC base of the general purpose IC test board.
3 Make other circuit connections to the IC in Fig 2.
5 Repeat step 4 for the other three OR gates of the IC.
6 Write your conclusion about the condition of each OR gate in Table 3 based on the recorded output of gates.
7 Get the recorded readings checked up by your instructor.
Disconnect connections made at input and output of the gates. Allow the IC 7432 to remain plugged on the board for subsequent tasks.
Table 3

Truth table of OR-gate using IC7432
Logic Input Output logic at Pin No.
A B 3 6 8 11
Gate-1 Gate-2 Gate-3 Gate-4
0 0
0 1
1 0
1 1
Condition of gate in the IC :4 Set switches SW1 and SW2 to apply input logic levels as in Table 3 to the first OR gate (Fig 2). Record the output logic level and verify its truth Table 3.
TI.C Type Total Input voltage Output voltage VCC/VDD Status Temperature
No. of no. of of IC range
package pins Logic- 0 Logic- 1 Logic- 0 Logic - 1 max. min.
7432
7402
TASK 3 : Construct AND gate using two switches with lamp and verify its truth table
1 Refer Fig 3 and construct the AND gate circuit using on a board switches and lamp test.
2 Get wired circuit checked by your instructor.
3 Apply different logic levels to the inputs A & B as given in Table 4 . Record the corresponding output logic level and lamp status.
4 Get the work checked by your instructor. 46
Table 4
Truth table of AND gate using switches and lamp
Input Output
Logic level Equivalent voltage level Logic level Voltage level LED status (ON/OFF) given as inputs
A B A B
0 0
0 1
1 0
1 1
open open
TASK 4 : Construct and test an AND gate using IC (7408)
1 Make circuit connections (Fig 4) using IC 7408 (AND).
2 Apply different logic levels to the inputs A and B to gate-1 (between pins 1 & 2) and record output (pin 3).
3 Repeat step 2 for the other AND gates in the IC 7408 by suitably modifying the circuit at input & output.
4 Conclude the condition of the IC in sheet after verifying truth table at Table 5.
5 Get the work checked by your instructor.
Table 5
Truth table of AND gate IC-7408
Input Output Y = A·B
Logic level Y1 Y2 Y3 Y4

A B (pin 3) (pin 6) (pin 8) (pin 11)
0 0
0 1
1 0
1 1
Condition of gate
TASK 5 : Construct a NOT gate using discrete components and verify its truth table
1 Construct the NOT gate using discrete components as shown in Fig 5 on the general purpose PCB. Get it checked by your instructor.
2 Power ON the circuit, by applying 5V Fig 5. Apply logic level-0 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.
When the input terminal of the circuit is grounded, it is equivalent to applying logic 0.
Note that keeping input terminals open is not equal to logic 0 level.
3 Apply logic level-1 to the input (see note below) and record the voltmeter reading, its equivalent logic level and the status of LED.

When the input of the circuit is connected to +5V, it is equivalent to applying logic 1.
4 Repeat steps 3 & 4 a few times to confirm the recorded values and to have a clear understanding of the logic levels and concept of inversion logic.
5 Get the working of the NOT gate and confirm the recorded readings (Table 5) checked by your instructor.
Table 5
Input Output
Logic Voltage Logic Voltage LED status
level level level level ON/OFF
TASK 6 : Verify the truth table of a Transistor-Transistor Logic (TTL) NOT gate IC 7404
1 Record the following details for the given IC 7404.
• Manufacturer’s name
• IC number
• Type of package
• IC family type
• Internal connection diagram with pin numbers.
Referring to Fig 6 of exercise and IC data book, note down the following readings in Table- 6
Table 6
a IC number : _____

b Manufacturer name : _____
c Number of pins : _____
d Type of package : _____
e IC family type : _____
f Internal block diagram with pin numbers and details: _____

2 Referring IC data book complete the details given in Table 7 and get it checked by the instructor.

3 Test the IC using digital IC tester to confirm its good working condition. Exchange IC if found defective.

4 Construct the NOT gate test circuit shown in Fig 6 on the general purpose IC test board/pin board. Get the constructed circuit checked by your instructor.

5 Insert the IC in the IC base of the wired circuit. Make sure IC inserted as per circuit.

6 Switch on the DC supply (+ 5V) to the wired circuit and check if the IC is getting excessively heated-up. If the IC is getting heated up, switch-off power supply and consult your instructor.

Table 7

1 IC 7404 has got _____ inverters.

2 Maximum I/P voltage level for Logic-0 is _____ volts.

3 Minimum I/P voltage level for Logic-1 is _____ volts.

4 Maximum O/P voltage level for Logic-0 is _____ volts.

5 Minimum O/P voltage level for Logic-1 is _____ volts.

6 In IC 7404, the VCC and ground pins are _____ and _____ respectively.

7 Measure voltage level at VCC and GND pins at the IC to confirm that supply is reaching the IC.

8 Apply Logic 0 (Low/Ground/ 0 volt) to the input of the inverter 1 of wired IC NOT circuit. Record the output voltage, corresponding logic level and status of LED in Table 8.

9 Give logic 1 (High/+ 5V) at the input of the same inverter and record the outputs as done in step 8.

10 Get the recorded readings checked by your instructor.

11 Modify the wiring of the circuit to test the next NOT gate between pins 3 & 4. Get it checked by your instructor.

12 Repeat steps 8, 9 and 11 to test other NOT gates of the IC.

If any gate is found to be defective, record it

and consult your instructor.
13 Get your work checked by your instructor.
Do not dismantle the circuit. This is required
for next exercise.
14 Repeat steps 1 to 12 for the CMOS NOT gate IC,
CD4079 following the instructions given below;
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.1.173

– Construct the circuit in a different place on the same
board.
– After setting up the circuit get it checked before
proceeding further.
– Use 12 volts DC for VCC.
– For CMOS ICs, Logic-1 can be equal to VCC.
The minimum logic-HIGH input voltage should be
= 2/3 VCC. and, maximum logic-LOW input voltage
can be = 1/3 VCC.
15 Get the work c

generate and demonstrate wave shapes for voltage and current of rectifier,
single stage amplifier and oscillator, using CRO
Objectives: At the end of this exercise you shall be able to
• construct a bridge rectifier test the output wave form
• test the wave shape without RC filter and with filter and calculate ripple factor
• test the wave shapes of a common smith amplifiers and distinguish with the input &
output waves
• test the oscillator output wave shape and identify the frequency

Requirement

Tools/Instruments
• Trainees kit - 1 No.
• Oscilloscope, 20MHz, dual trace - 1 No.
• Voltmeter MC 0-30V - 1 No.
• Multimeter - 1 No.
• Soldering iron 25W 240V - 1 No.
• Function generator - 1 No.
• Regulated DC power supply 12V/1A - 1 No.
Materials/Components
• Lug board General purpose 5 points - 1 No.
• Diode IN4007 - 4 Nos.
• Resistor 470Ω - 1 No.
• Step-down transformer,
240V 24V 500mA - 1 No.
• Multi strand wire, red, blue

19/0.3 of 600V grade - as reqd.
• Base board - 1 No.
(Laminated board 30 x 15 x 3mm)
• Nuts, bolts and washers - as reqd.
• 3 Pin plug 6A 250V - 1 No.
• Resin core solder 60/40 - as reqd.
• Electrolytic capacitor 10 µFD/25V - 1 No.
• Resistor 10K/1W - 1 No.
• Transistor BF 195 - 1 No.
• Capacitors - 0.01and 0.1µfd - 3 Nos.
• Gang capacitor 25-2J - 1 No.
• Resistors - 82K, 18K, 3.9K, 390Ω/1/4W - 1 each
• Medium wave oscillator coil - 1 No.
• Transistor, SL 100 or equivalent - 1 No.
Diode IN914/OA79
• Capacitor, 100 µF/25 V, electrolytic, - 1 No.
axial
• Capacitor, 25 µF/25 V, electrolytic, - 2 Nos.
axial
• Resistors 1/4 W, carbon
120 Ω - 1 No.
470 Ω - 1 No.
1.2 KΩ - 1 No.
5.6 kΩ - 1 No.
• Hook-up wiresROCEDURE
TASK 1: Construct a bridge rectifier and test the wave shapes with and without filter and calculate ripple
frequency
1 Construct a bridge rectifier, referring to the schematic and layout diagrams. (Fig 1a & 1b)
2 Switch ON the circuit. Measure and record the AC input Vs(rms) to the rectifier in Table 1
3 Calculate the expected output DC voltage Vdc across load RL using the formula. Vdc = 0.9 Vs(rms) where, Vs(rms) is the AC input to the rectifier (refer Fig 1a). Record the value in Table 1.
4 Measure the DC output V dc across the load R L and record it in Table 1.
5 Record the difference in the calculated and measured values in Table 1. Get it checked by your instructor.
6 Measure and record the following parameters in Table 1 by using a CRO.
- peak value of Vs_____
- frequency of Vs_____
- peak value of the pulsating Vdc_____
- frequency of pulsating Vdc _____
- Wave forms of output and input voltages.
7 Show the waveforms and record the readings to your

instructor before switching off mains supply and CRO.

Table 1
Readings of two-diode full-wave rectifier
Vs(rms) Calculated Measured Difference of Peak value Frequency Peak value of Frequency
Vdc volts Vdc volts (2) & (3) of Vs of Vs pulsating Vdc pulsating Vdc
(1) (2) (3) (4) (5) (6) (7) (8)
TASK 2: Measure of ripple and calculate ripple factors in bridge rectifiers with RC filter
1 Construct the filter circuit in the bridge rectifies already constructed. (Fig 2)
2 Repeat the steps 2 to 6 of task 1. Enter the measured values in Table 2 and 3.

Table 2
Condition Input AC Output DC AC ripple Ripple factor
Without RC filter
With RC filter
voltageDC
voltagerippleAC
=
Table 3
Condition
Output wave form without capacitor
Output wave form with capacitor
TASK 3 : Determine the voltage gain A2 of CE amplifier and distinguish input and output wave shapes
1 Construct the circuit of CE amplifier in Fig 3.
2 Apply Vcc measure and record Ic and IB in Table 4.
3 Apply input sinewave from function generator and measure voltage gain of using CRO. Observe the input and output waves.
4 Record the input and output wave shapes of the CE amplifiers.
5 Get it checked with your instructor.
Table 4
Transistor Collector IC Base V gain Input wave Output wave Relation between
Number current current IB shapes shapes input & output wave
TASK 4 : Assemble a hartley oscillator and test the waves, find frequency with different capacitor values
1 Test the components to confirm their good working condition.
2 Assemble the Hartley oscillator circuit referring to Fig 4.

3 Connect and switch ON + 12V-DC supply to the wired circuit. Check to ensure that the transistor is not getting heated-up.
If the transistor is getting heated-up, switch-OFF supply and consult your instructor.
4 Connect the secondary terminals of the MW OSC coil, to CRO set to measure the frequency.
5 Adjust CRO time-base to get a clear sinusoidal wave on the screen. Measure the amplitude and frequency of oscillations and record the observations below:
i) amplitude of oscillations
ii) Frequency of oscillations
If oscillations are not seen, tune the gang capacitor. If oscillations are still not seen, consult your instructor.
6 Get the working of the oscillator checked by your instructor.

7 Set the gang capacitor to one extreme end. Measure the amplitude and frequency of oscillations and enter in Table 5.
8 Set the gang capacitor to the other extreme end. Measure the amplitude and frequency of oscillations and enter in Table 5.
9 Set the position of the gang capacitor to approximately mid-position. Measure the amplitude and frequency of oscillations and enter in Table 5.
10 Get the recorded reading checked by your instruc

Electrical Exercise 4.2.175 (i)
Electrician - Control Panel Wiring
Design layout of control cabinet, assemble control elements and wiring accessories for local and remote control of induction motor
Objectives: At the end of this exercise you shall be able to
• draw the control and power circuit for remote control
• mark the layout on control panel wiring accessories remote control
• drill and tap for fixing accessories
• mount the DIN rail and accessories
• wire up the accessories
• arrange the wiring by routing, bunching and tying
• test the control panel for local and remote control of induction motor.

Tools/Instruments
• Trainees tool kit - 1 No.
• Scriber 100 mm - 1 No.
• Hacksaw frame with blade- 300 mm - 1 No.
• Hand drilling machine 6mm capacity - 1 No.
• HSS Drill bit 6mm & 4mm - 1 No.
each
• Round nose plier 150 mm - 1 No.
• Crimping tool 200 mm - 1 No.
Instruments/Equipments
• Digital multimeter - 1 No.
• Megger 500V - 1 No.
• Contactor 4 pole, 16A,240V - 1 No.
• Thermal overload relay 10A, 415V - 1 No.
• Remote station - 1 No.
• Over load relay 15A, 415V - 1 No.
Materials
• Push button red /green - 1 each
• Indicator lamp with holder - 1 each
(red, yellow, blue)
• MCB 4 Pole 16A , 415V - 1 No.

• Race ways - 1 m
• DIN rail - 1 m
• G - channel - 2 m
• Wire clips - as reqd.
• Terminal connectors - as reqd.
• Wire ferrule - as reqd.
• Grommets - as reqd.
• Lug/thimble - as reqd.
• Cable binding straps and buttons - 10 m
• Nylon cable ties - 15 Nos.
• PVC 1.5 sq mm copper cable 660V - as reqd.
(red, black, yellow, blue, green)
• Assorted size bolt & nutPROCEDURE

TASK 1 : Identify the control accessories and wiring accessories used for control panel wiring

Instructor must serially arrange the real items of control elements used for control panel wiring, If it
is not possible provide the images without their names. He can explain how to identify them with
specification and uses / types.

1 Identify the control elements from the real objects (or)
from the images.

2 Write the name and type of the control elements
against the space provided and also write their
specification and purpose / application in Table 1.

3 Check the identified items with your instructor.

Sl. No.	Names of control elements and wiring accessories (from real or image)	Types of the elements (whether protective / control etc.)	Specifications	Purpose / Application
1				
2				
3				
4				
5				
6				
7				
8				

Fig 2
CONTROL PANEL WITH RACE WAYS/DIN RAILS
ELN42175U2
Table 1

TASK 2 : Develop the layout and mark the layout in control panel

Note : Instructor has to provide a blank control
panel along with power and control circuit of
the local and remote control of induction motor.

1 Draw the layout diagram
2 Select and check the accessories required.
3 Mark the layout inside the control panel by using steel rule and scriber.
4 Mark for fixing holes for isolators and control devices etc., as per layout diagram.
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.
6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.
7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)
8 Make the drills in side the control panel to fix control devices, DIN rails, 'G' channel and race ways as per marking.
2 Make the through holes in race ways, DIN rails and G channel.
3 Fix the control accessories race ways, DIN rails and G channel using fixing screw, bolt and nuts.
4 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking. (Fig 2)
TASK 3 : Draw and wire the control and power circuit for local and remote control of induction motor
1 Draw the control circuit and power circuit and check and verify with your instructor. (Fig 3 and 4)
2 Label the Terminal number in the control and power circuit.
3 Measure and cut the cable as per layout.
4 Insert the ferrule Nos at the both ends of terminals as per layout and run the wires in the race ways one by one. Avoid the cross over of the wires.

A typical control panel fitted with race ways, DIN rails, control transformer and isolator is shown in Fig 5.
Leave some extra length of wires in the race ways for easy maintenance and repair.
To avoid the cross - over first the vertical wires can be run followed by horizontal run.
5 Skin the wire ends and crimp with suitable lugs/ thimbles.
6 Connect the control circuits wires as per the control circuit and terminals / ferrule tabl

Connect the incoming and out going terminals as per diagram and terminal details.
Use the grommets to avoid the strain in the cables.
13 Earth the panel and door.
14 Measure the insulation resistance of the panel.
If the IR value is less than 1 Meg ohm, take suitable remedy action.
15 Set the OLR in accordance with the full load current of motor.
A typical control panel with complete wiring is shown in Fig 6.
Fig 6
CONTROL PANEL WITH COMPLETE WIRING ELN42175H6
16 Test the local and remote control of motor.
17 Show and check the control operation with your instructor.
After removing the wiring, get it verified by the instructor and preserve all the fittings for subsequence exercises.

Electrical Exercise 4.2.175 (ii)
Electrician - Control Panel Wiring
Design layout of control cabinet, assemble control elements and wiring accessories for forward and reverse operation of induction motor
Objectives: At the end of this exercise you shall be able to
• draw the control and power circuit for forward and reverse operation of motor
• mark the layout on control panel
• wire up the accessories
• arrange the wiring by routing, bunching and tying
• test the control panel for forward and reverse of induction motor.

Procedure

Tools/Instruments
• Trainees tool kit - 1 No.
• Scriber 100 mm - 1 No.
• Hacksaw frame with blade- 300 mm - 1 No.
• Hand drilling machine 6mm capacity - 1 No.
• HSS Drill bit 6mm & 3mm - 1 No. each
• Round nose plier 150 mm - 1 No.
• Crimping tool 200 mm - 1 No.
Instruments/Equipments

• Digital multimeter - 1 No.
• Megger 500V - 1 No.
• Air break contactor 4pole, 16A, 240V - 2 Nos.
• Overload relay 15A, 415V - 1 No.

Materials

• Push button red /green/yellow - 1 each
• Indicator lamp with holder - 5 Nos.
• MCB 4 Pole 16A - 1 No.
• Race ways - 2 m
• Wire clips - 4 Nos.
• DIN rail /G - channel - 1 m
• 1.5 sq.mm copper cable 660V
(red, black, yellow, blue, green) - as reqd.
• Terminal connectors - as reqd.
• Wire ferrule - as reqd.
• Grommets - as reqd.
• Lug/thimble - as reqd.
• Cable binding straps and buttons - as reqd.
• Nylon cable ties - 10 Nos.
• Assorted size bolt and nut

PROCEDURE

The control panel board used in the Ex.4.2.175(i) has to be retained with accessories fitted to use for this
Exercise.

TASK 1 : Draw the layout and mark the layout in control panel

1 Draw the layout diagram for the forward and reverse control of induction motor.
2 Select and check the accessories required.
3 Mark the layout inside the control panel by using steel rule and scriber for the additional accessories.
4 Mark holes for fixing control for accessories etc., as per layout diagram. (Fig 1)
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.
6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.
7 Mark the holes for fixing the wire clip

Fix the control accessories, race ways, DIN rails and ‘G’ channel using fixing screw and bolt nuts.
9 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking in Fig 2.

TASK 2 : Wire the control and power circuit for forward and reverse (F/R) control of induction motor

1 Draw the control and power circuit and check the correctness. (Fig 3 & 4)
2 Label the Terminal number in the control and power

circuit.
3 Measure and cut the cable as per layout.
A typical control panel fitted with race ways,
DIN rails, control transformer and isolator etc.
is in Fig 5.
4 Insert the ferrule Nos at the both ends of terminals as
per layout.
Leave some extra length of wires in the race
ways for easy maintenance and repair.
5 Run the wires in the race ways one by one. Avoid the
cross over of the wires.
To avoid the cross-over, run the vertical wire
first, followed by horizontal runs.
6 Skin the wire ends and crimp with suitable lugs/
thimbles
7 Connect the control and power circuits as per circuit
diagram. (Fig 3 & 4)
8 Route the wires in the race ways. Punch and ties the
wires in the race ways using cable binding straps and
button.
Leave the excess wires if any in the bends or
in the race ways.
9 Cover the PVC race ways over the wiring.
Take the necessary care to avoid the crushing
of cable when cover the race ways.
10 Make the "U" loops of wires in the hinged doors. Bunch
and tie the cable on the doors.
11 Fix the wire clips at suitable places to hold the cables
in the panel door.
Ensure the ‘U’ loop should not disturb the
movement and closing of the panel door.
12 Connect the incoming and out going terminals as per
diagram and terminal details.
Use the grommets to avoid the strain in the
cables.
13 Earth the panel, door and metal devices.
14 Measure the insulation resistance of the panel.
If the IR value is less than 1 Meg ohm, take
suitable remedial action.
15 Set the Over Load Relay (OLR) in accordance with the
full load current of motor.

Electrician - Control Panel Wiring
Design layout of control cabinet, assemble control elements and wiring
accessories for automatic star-delta starter with change of direction of

rotation

Objectives: At the end of this exercise you shall be able to

• draw the control and power circuit of automatic star delta starter with change of direction of rotation
• mark the layout on control panel
• mount the DIN rail and accessories
• wire up the accessories
• arrange the wiring by routing, bunching and tying
• test the control panel for automatic star-delta starter with change of direction of rotation

Requirement

Tools/Instruments

• Trainees tool kit - 1 No.
• Scriber 100 mm - 1 No.
• Hacksaw frame with blade- 300 mm - 1 No.
• Hand drilling machine 6mm capacity - 1 No.
• HSS Drill bit 6mm & 3mm - 1 No.
• Round nose plier 150 mm - 1 No.
• Crimping tool 200 mm - 1 No.

Instruments/Equipments

• Digital multimeter - 1 No.
• Megger 500V - 1 No.
• Contactor 4 pole,16A,240V,2No+2NC - 5 Nos.
• Timer 1 No+ 1 INC relay - 1 No.

Materials

• Push button green/red/green - 1 each
• Indicator lamp with holder - 5 Nos.
• Overload relay 0-15A, 415V - 1 No.
• MCB 3 Pole 25A , 415V - 1 No.
• Race ways - 2 meter
• Wire clips - 4 Nos.
• 1.5 sq.mm copper cable 650V - as reqd.
(red, black, yellow, blue, green)
• Terminal connectors - as reqd.
• Wire ferrule - as reqd.
• Grommets - as reqd.
• Lug/thimble - as reqd.
• Cable binding straps and buttons - as reqd.
• Nylon cable ties - 10 Nos.
• Assorted size bolt and nut - aPROCEDURE

The control panel board used in the Ex.No.4.2.175(ii) has to be retained with accessories fitted to use
for this exercise.

TASK 1 : Draw the layout and mark the layout in control panel

1 Draw the layout diagram for the automatic star delta

starter with change of direction of rotation.
2 Select and check the accessories required.
3 Mark the layout inside the control panel by using steel rule and scriber.
4 Mark for fixing holes for control accessories etc., as per layout diagram. (Fig 1)
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.
6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.
7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)
Fig 1
CONTROL PANEL WITH FIXING DRILL HOLES
ELN42175U1

8 Make the drills in side the control panel to fix control accessories, DIN rails, 'G' channel and race ways as per marking.
9 Make the through holes in race ways, DIN rails and G channel.
10 Fix the control accessories race ways, DIN rails and G channel using screws and bolt nut.
11 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking. (Fig 2)
Fig 2
CONTROL PANEL WITH RACE WAYS/DIN RAILS
ELN42175U2
TASK 2 : Wire the control and Power circuit for automatic star delta starter with change of direction of rotation
and test.
1 Draw the control circuit and power circuit diagram and check with your Instructor. (Fig 3 & 4)

2 Label the Terminal number in the control and power circuit.
3 Measure and cut the cable as per layout.
A typical control panel fitted with race ways,

Electrical Exercise 4.2.175 (iv)
Electrician - Control Panel Wiring
Design layout of control cabinet, assemble control elements and wiring accessories for sequential control of three motors
Objectives: At the end of this exercise you shall be able to
• draw the control and power circuit for sequential control of three motors
• mark the layout on control panel

• mount the DIN rail and accessories
• wire up the accessories
• arrange the wiring by routing, bunching and tying
• test the control panel for sequential control of 3 moto

Requirement

ools/Instruments
• Trainees tool kit - 1 No.
• Scriber 100 mm - 1 No.
• Hacksaw frame with blade- 300 mm - 1 No.
• Hand drilling machine 6mm capacity - 1 No.
• HSS Drill bit 6mm & 3mm - 1 No.
each
• Round nose plier 150 mm - 1 No.
• Crimping tool 200 mm - 1 No.
Instruments/Equipments
• Digital multimeter - 1 No.
• Megger 500V - 1 No.
• Air break contactor 4 pole,16A,240V - 3 No.
• Thermal overload relay 0 -15A, 415V - 3 Nos.
• Control transformer 415V/240V,200VA - 1 No.
• Time control transformer 415V,
1 No + 1 NC - 2 Nos.
Materials
• MCB 4 pole, 415V, 16A - 1 No.
• Push button Red /Green - 1 each
• Indicator lamp with holder - 7 Nos.
• Limit switches 1NO+INC - 2 Nos.
• Fuse base with carrier - 9 No.
• MCB 2 Pole 4A - 1 No
• MCB single pole 2A - 1 No.
• Race ways - 2 m
• Wire clips - 4 Nos.
• DIN rail/ G channel - 1 m
• 1.5 sq.mm copper cable 660V
(red, black, yellow, blue, green) - as reqd.
• Terminal connectors - as reqd.
• Wire ferrule - as reqd.
• Grommets - as reqd.
• Lug/thimble - as reqd.
• Cable binding straps and buttons - as reqd.
• Nylon cable ties - 10 Nos.
• Assorted size bolt and nut - as reqd.
PROCEDURE
The control panel board used in the Ex.No.4Draw the layout diagram for the sequential control of
three motors.
2 Select and check the accessories required.

3 Mark the layout inside the control panel by using steel rule and scriber.
4 Mark for fixing holes for isolators and control transformer etc., as per layout diagram.
5 Mark and cut the DIN rail, 'G' channel and race ways as per layout. Mark the points of drills on it to fix them inside the control panel.
6 Mark the drill holes in the front door of the control panel to fix the indicator lamp and push button switches.
7 Mark the fixing holes for the wire clips in the control panel door to run the wires. (Fig 1)
8 Make the drills in side the control panel to fix isolator, control transformer, DIN rails, 'G' channel and race ways as per marking.
9 Make the through holes in race ways, DIN rails and G channel.

10 Fix the race ways, DIN rails and G channel using fixing screw.
11 Make the drills on the door of panel for indicator lamp, push button and wire clips as per marking.
(Fig 1 and 2)
Fig 2
CONTROL PANEL WITH RACE WAYS/DIN RAILS
ELN42175X2
TASK 2 : Wire the control and Power circuit for sequential control of three motors and test
1 Draw the control and power circuit diagram and check with your Instructor. (Fig 3 and 4) 2 Label th

wires in the race ways using cable binding straps and button.
Leave the excess wires if any in the bends or in the race ways.
9 Cover the PVC race ways over the wiring.
Take the necessary care to avoid the crushing of cable when covering the race ways.
10 Make the "U" loops of wires in the hinged doors. Bunch and tie the cable in the doors.
11 Fix the wire clips at suitable places to hold the cables in the panel door.
‘U’ loop should not disturb the movement and closing of the panel door.
12 Connect the incoming and out going terminals as per diagram and terminal details.
Use the grommets to avoid the strain in the cables.

13 Earth the panel, door, control transformer and motors.
If the multiple earths are used, use a common
earth terminals and strips.
14 Measure the insulation resistance of the panel.
If the IR value is less than 1 Meg ohm, take
suitable remedial action.

15 Set the OLR in accordance with the full load current of
motor.
A typical control panel with complete wiring is
shown in Fig 6.
15 Test the control panel for sequential operation of 3
motors.
Note: Remove the wiring and preserve the
remaining control elements fitted with panel
for the next exercise No. 4.2.176.
16 Report and get it checked with your instructor.
Fig 6
CONTROL PANEL WITH COMPLETE WIRING ELN42175X6

Electrical Exercise 4.2.176
Electrician - Control Panel Wiring
Carryout wiring of control cabinet as per wiring diagram, bunching of XLPE cables channeling, tying and checking etc.
Objectives: At the end of this exercise you shall be able to
• verify the wiring diagram panel board and wire up
• bunch the Cross Linked Polyethylene (XLPE) cables

Requirement

Tools/Equipments/Instruments
• Trainees tool kit - 1 No.
• Multimeters - 1 No.
• Wire cutter/stripper - 1 No.
Materials
• Panel board - 3’x2’x1’ - Metal box
with winged front door - 1 No.
• DIN rails/race ways - as reqd.
• Screws, nuts and bolts - as reqd.
• Tying clips - as reqd.
• Ferrule - as reqd.
• PVC channel - as reqd.
• G channel - as reqd.

• Terminal connector - as reqd.
• Belt traps - as reqd.
• XLPE cable 1.5 sq.mm 600V - as reqd.
• 1 sq.mm cable (copper) - as reqd.
• Wire sleeves - as reqd.
• Wire clips - as reqd.
• Grommets - as reqd.
• Banana sockets (5 mm)

PROCEDURE

TASK 1 : Wire up control cabinet as per diagram with bunching, channeling, typing and checking etc.

The control panel board used in the Ex.No.4.2.175(iv) has to be retained with control accessories fitted
is to used for this exercise. For the wiring XLPE cables to be used.

1 Draw the wiring diagram and wire up as per the
diagram.

Follow the colour coding of cables used for
line controller, neutral and ground
connections.

Inter connections of devices may be used
same colour. Supply line, load line should he
colour coded and numbered using ferrule.

2 Bunch the XLPE cables by using the tie clips and wire
clips. (Fig 1)

3 Apply belt traps for excessive bunch of cables.

4 Make a U loop on the bunch of cables when it is
connected to front door. (Fig 2)

5 Cut excessive tie ends and other excessive parts to
make a neat bunching of cables.

Clean the panel board and preserve for next
Exercise No.4.2.177.

6 Show the work done on the panel board to your
instructor and get approval.

Fig 1

CONTROL PANEL WITH RACE WAYS/DIN RAILS
ELN42176H1

7 Check the wiring for its correctness.

Fig 2

CONTROL PANEL WITH COMPLETE WIRING ELN42176H2

TASK 2 : Connect the control panel with 3 phase induction motor

1 Draw the circuit diagram for the control panel with 3
phase induction motor. (Fig 3)

2 Wire up the control panel to the 3 phase motor in
conduct wiring.

3 Provide double earthing for the motor.
4 Test the wiring for the proper operation of control panel controls with motor.
5 Check the controls of control panel for changing the direction of rotation of motor.
6 Get it checked with your instructo

Electrical Exercise 4.2.177
Electrician - Control Panel Wiring
Mount various control elements (e.g) circuit breakers, relays, contactors and timers etc.
Objectives: At the end of this exercise you shall be able to
• drill the holes in the marked places
• Mount the circuit breakers, relays, contactors and timer
• connect the cables to the control elements

requirement

ools/Equipments/Machines
• Trainees tool kit - 1 No.
• Multimeter - 1 No.
• Wire cutter/striper - 1 No.
• Needle file set - 1 Set.
• Round file set - 1 No.
• Hand drilling machine (electric) 6mm - 1 No.
• Half round file smooth-150 mm - 1 No.
• Flat file smooth-150 mm - 1 No.
Materials
• MCB 4 pole, 415V/16A - 1 No.
• OLR- 3 phase 415V/0-15A - 1 No.
• Contactors - 3 phase, 415V/16A
240V coil - 5 Nos.
• Timer - 1 phase, 10 sec - 2 Nos.
• Push button - 240V, NC/NO red & green - 4 Nos
• Indicating lamp with holder RYB - 3 Nos.
• Limit switch - 1 No.
• ON-OFF rotary switch 3 phase 3

Electrical Exercise 4.2.177
Electrician - Control Panel Wiring
Mount various control elements (e.g) circuit breakers, relays, contactors and timers etc.
Objectives: At the end of this exercise you shall be able to
• drill the holes in the marked places
• Mount the circuit breakers, relays, contactors and timer
• connect the cables to the control elements.
Requirements
Tools/Equipments/Machines

• Trainees tool kit - 1 No.
• Multimeter - 1 No.
• Wire cutter/striper - 1 No.
• Needle file set - 1 Set.
• Round file set - 1 No.
• Hand drilling machine (electric) 6mm - 1 No.
• Half round file smooth-150 mm - 1 No.
• Flat file smooth-150 mm - 1 No.

Materials

• MCB 4 pole, 415V/16A - 1 No.
• OLR- 3 phase 415V/0-15A - 1 No.
• Contactors - 3 phase, 415V/16A
240V coil - 5 Nos.
• Timer - 1 phase, 10 sec - 2 Nos.
• Push button - 240V, NC/NO red & green - 4 Nos
• Indicating lamp with holder RYB - 3 Nos.
• Limit switch - 1 No.
• ON-OFF rotary switch 3 phase 32A - 1 No.

PROCEDURE

The panel board used in the Ex.No.4.2.176 is to be used for this exercise.

TASK 1: Mark and make holes for mounting devices

1 Measure the total area of base plate on four panel board, where devices are to be mounted.

2 Identify and check the area required to mount the devices like circuit breaker, contactor, push button, OLR, ON-OFF rotary switch, Timer, etc: as per the total quantity available.

3 Mark the plates where to fix the DIN rail and race ways to mount circuit breaker, contactors. (Fig 1)

While marking the layout for mounting devices, it is distributed equally to the whole area uniformly. Do not fix all the items in one end. Keep some space for future needs.

4 Make hole by electric drill to the size of nut and bolts. If the bolt is not free in through holes, use needle round file or bigger bits to make the bolt free going.

5 Fix the devices according to the layout on base plate check each devices for its rigidity and position correctness and get it checked.

TASK 2: Connect cables to control devices and checking the continuity

1 Check the XLPE cables for continuity and tighten before connecting to the device.

2 Connect all the cable to the respective terminals and connecting points to the devices, fitted on the base plate.

3 Connect the relay coil, contactor coil, etc to a external source of working voltage and confirm the function especially in the Normally Close (NC) and Normally

Open (NO) no contacts of push buttons and
contactors.
4 Report to your instructor for approval.

Electrical Exercise 4.2.178
Electrician - Control Panel Wiring
Identify and install required measuring instruments and sensors in control panel
Objectives: At the end of this exercise you shall be able to
• identify and fix instruments to measure electrical quantities
• identify the sensors and fix it on the panel board.
Requirements
Tools/Equipments/Machines
• Trainees tool kit - 1 No.
• Wire cutter/striper - 1 No.
• Hard drilling machine (electrical) 6mm - 1 No.
• Needle file set (set of 5) - 1 Set.
• Round file smooth - 150 mm - 1 No.
• Flat file smooth - 150 mm - 1 No.
• Tachometer - digital - 3 1/2 digit
along with tacho generator set - 1 No.
• Single phase frequency meter
digital - 3 1/2 digit - 1 No.
• Temperature indicator - digital
3 1/2 digit - along with thermister
sensor unit - 1 No.
• Voltmeter - 0-600V - digital - 1 No.
• Voltmeter - 0-300V - digital - 1 No.
• Ampere meter 0-30A digital 31/2 digit - 3 Nos.
Materials
• Nut and bolt (Assorted sizes) - as reqd.
• Washer (Ordinary & spring type)
difficult sizes - as reqd.
• 1 sq.mm cable - as reqd.
PROCEDURE
The panel board used in the Ex.No.4.2.177 is to be used for this exercise with accessories.
TASK 1: Fix panel meters and indicators on front panel
1 Identify and select proper range of instruments
(voltmeter, ammeter etc.,) suitable for this control
panel.
2 Identify and select the required sensors (for
temperature and speed) for this control panel.
The control devices are fitted on base cover
and indicators are to be fitted on front panel.
Wiring is terminated in respective points to be

connected in the instruments. Proper sockets for terminating sensor outputs are to be provided on the front panel.

3 Mark the positions to fix the indicators on front panel (Line indicators, tripping indicators etc.)

4 Make holes for fixing the meters and other fixtures on front panel.

5 Fix the meters and indicators on front panel. Distribution of gadgets on fixing in front panel should be uniform. Proper arrangement and distribution to have a good look on the front panel required. Do not crowed the devices at one places, and indicate devices like line indicator, trip indicator should be at top of the front panel as in Fig 1.

6 Wire the fitting in front panel using suitable cables. Bunching or typing cables in front panel board is to be done if necessary.

7 Check the continuity of cables wired inside the panel board.

8 Report to your instructor.

lectrical Exercise 4.2.179

Electrician - Control Panel Wiring

Test the control panel for its performance

Objectives: At the end of this exercise you shall be able to

• test the control panel for any short circuit earthing with fitted devices

• test the earthing points connections with connected control devices

• energise and test the panel board for its working condition.

Requirements

Tools/Equipments/Machines

• Trainees tool kit - 1 No.

• Megger 1000V - 1 No.

Materials

• Connecting leads - as reqd.

PROCEDURE

The panel board used for the Ex.No.178 is to be used for this Exercise with complete accessories and wiring.

The panel board with accessories and wiring is to be preserved for this Exercise No.4.2.179

1 Check the Insulation Resistance (IR) value of contactors circuit breakers etc, (Fig 1) enter the values in Table 1.

2 Check for any short circuit/open circuit fault.(Fig 1) If any IR value shows abnormal or very low, consult with your instructor.

3 Switch ‘ON’ the supply to the panel board and verify the functions of line indicator, meters etc.

4 Test the contactor, push button switch, timer for its function. Enter the status in Table 1.
5 Switch ‘ON’ the motor and check the functions of sensors (speed and temperature)
If any control device found faulty replace ne

s	Description of the items	Megger value Condition in M ΩΩΩΩΩ
	Overload relay	
	2 Contactor	
	3 Circuit breaker	
	4 Voltmeter	
	5 Ammeter	
	6 Frequency meter	
	7 Temperature indicator	
	8 Tachometer/revolution counter	
	9 Indicator	

Electrical Exercise 4.3.180
Electrician - AC/DC Motor Drives
Perform speed control of DC motor using thyristors/DC drive
Objectives : At the end of this exercise you shall be able to
• read and interpret the name plate details of DC drive
• connect the input/ output terminals of DC drive to motor operate the load
• control the motor speed by using DC drive and operate motor with 1/4th, 1/2th, 3/4th, load
• reverse the DOR by using DC drive and operate motor with different speed

ools/Instruments
• Insulated combination pliers 150 mm - 1 No.
• Screw driver 200 mm - 1 No.
• Connector screw driver 100 mm - 1 No.
• Electrician’s knife 100 mm - 1 No.
• Round nose plier 150 mm - 1 No.
• MC voltmeters - 0 - 250 V - 1 No.
Equipment/Machines
• DC motor 3 HP, 220V coupled with
DC generator 2KW, 220V - 1 N

ROCEDURE
TASK 1: Connect the input/ output terminals of DC drive to DC motor to operate the load
1 Note down name plate details of the given motor
DC drive and lamp load. (Table 1, Table 2 and Table 3)
Electrical Exercise 4.3.180
Electrician - AC/DC Motor Drives
Perform speed control of DC motor using thyristors/DC drive
Objectives : At the end of this exercise you shall be able to
• read and interpret the name plate details of DC drive
• connect the input/ output terminals of DC drive to motor operate the load
• control the motor speed by using DC drive and operate motor with 1/4th, 1/2th, 3/4th, load
• reverse the DOR by using DC drive and operate motor with different speed.
2 Check and identify terminals of the DC motor and DC
drive.
Table 1
DC Motor name plate - details
Manufacturer _____ Speed _____RPM
Make _____ Insulation class _____
Armature voltage _____V Rated current

_____A
Field voltage _____V
Power _____KW/HP
Table.2
Name plate details of DC drive
1 Rated supply voltage armature V
2 Rated input current armature A
3 Rated supply voltage electronics supply V
4 Rated supply voltage field V
5 Rated frequency Hz
6 Rated DC current A
7 Overload capability A
• Lamp load : 2000 W (500W x 4) - 1 No.
• DC drive 3HP, 220V - 1 No.
Materials
• PVC insulated strandard copper
cable 1.5 sq.mm, 660V - 15 m.
• PVC insulated flexible cable 14/0.2 mm - 3 m.
• Insulation tape - 1 No.

Table 2 (Contd.)
Name plate details of DC drive
8 Rated output KW
9 Power at rated DC current (approx.) w
10 Rated DC voltage field V
11 Rated DC current field A
12 Operational ambient temperature °C
13 Storage and transport temperature °C
14 Installation altitude above sea level °C
15 Dimensions (H x W x D) mm
Lamp load
Connect with main switch/MCB, 4 Nos of 500 W clear lamps fitted in a enclosure having individual ON - OFF facility.
Table 3
Make & SI.No
Rated Mains V
Rated Power KW
3 Remove the drive cover. Identify and trace the internal connection and get it approved by the instructor.
4 Select the ICTP switch /MCB, cables and fuse - wire according to the rating of the motor.
5 Draw the circuit diagram and connect the ICTP, MCB, drive and the motor, and get it approved by the instructor.(Fig 1)
6 Connect double earth independently for the main

switch, DC drive and the motor.
TASK 2 : Control the speed by setting the parameter of different load and speed
7 Check the supply and ensure for proper rating of fuses main switch according to the motor rating.
Improper connection of DC drives leads to shock and material damage.
1 Select the suitable type of model DC drive with code. (Fig 2)
2 Connect MCB, DC drive, M.G set and lamp load. (Fig 3)
3 Switch ON power supply.
4 Press ON button and measure the speed of the motor by using the Tachometer before loading. Record the readings in Table 4.
5 Load the motor by 1/4 th load; by switching ‘ON’ one lamp.Record the current , voltage, frequency and voltage in load terminal, vary the speed and observe the readings.

SI.No Load Armature voltage Field v

Load the motor further and switch ON another lamp (Total load now (500 W + 500W=1000W). Record all the readings in Table 4. Vary the speed with 1/2th load and observe the readings and record in Table 4.
7 Load further to 3/4th load (500+ 500 + 500=1500W) and repeat step 5 and record the reading in Table 4.
Switch 'OFF' the motor instantly, if anything noticed irregular consult your Instructor.
8 If motor maintaining the rated frequency after loading 3/4th load. Load the motor to full load (500+ 500 + 500+500=2000W) condition and switch ‘ON’ all the four lamps . Record all readings and repeat step -5.
9 Press 'OFF' switch once it is over and check the readings you recorded.
If the frequency reduced considerably when the motor operates in higher loads; Do not run the motor. Consult with your instructor.
10 Remove all the connection and supply cables from the motor and supply.
11 Record your observations.
TASK 3 : Reverse the direction of rotation by using DC drive
1 Connect the AC supply to the input and output terminals of DC drive when the output terminals connected to armature and field of the motor,

without connecting load.
2 Switch 'ON' power supply main switch.
3 Press 'ON' key and note the direction of running (forward direction).
4 Press reversing key and check the changing of direction of rotation of DC motor.
Wait, until the motor will obtain stability and then change the DOR.
5 Press 'OFF' key to stop the drive.
6 Turn ‘OFF’ main power supply to DC drive and disconnect the DC drive.
Improper connection of DC drive results shock and material damage.
You may have DC drive of different model / make. So refer the drive instruction in manual and take help of your instructor.
The DC drive can be programmed through PC after loading the software in the PC.
The programming procedure /keys may differ according to make /model of the drive in your institute refer to the instruction m a n u a l before connecting the drive.

Electrical Exercise 4.3.181
Electrician - AC/DC Motor Drives
Perform speed control and reversing the direction of rotation of AC motors by using thyristors/AC drive
Objectives: At the end of this exercise you shall be able to
• read and interpret the name plate details of AC drive
• connect the input / output terminals of AC drive through AC motor
• identify the operating buttons on AC drive
• control the motors speed by using AC drive
• reverse the directions of rotation of 3 phase induction motor by using AC drive.
Requirements
Tools/Instruments
• Insulated combination pliers 150 mm - 1 No.
• Screw driver 200 mm - 1 No.
• Connector 100mm - 1 No.
• Electrician’s knife 100mm - 1 No.
• Round nose plier 150 mm - 1 No.
Equipments/Machines
• 3 Phase induction motor 5 H.P/415V - 1 No.
• AC drive 3 phase 415V, 2HP - 1 No.
Materials

• PVC insulated strandard
copper cable 1.5 sq.mm - 15 m
• PVC insulated flexible cable 14/0.2 mm - 2 m
• Insulated tape - 1 m
• Fuse wire - as reqd.

PROCEDURE

TASK 1 : Connect the input/output terminals of AC drive through AC motor

1 Note down the name plate details of the given motor and AC drive and enter them in Table 1 & 2.

2 Identify the terminals of the 3 - phase induction motor.

Table 1

AC motor name plate - details

Manufacturer_____

Model _____

Power _____ KW/HP

Voltage _____ Volt

Rated frequency _____ Hz

Speed _____ RPM

Insulation class _____

Rated current _____A

Table 2

AC drive name plate - details

Manufacturer _____ Model : _____

I/P voltage _____V

I/P frequency _____Hz

O/P frequency _____Hz

Serial Interface type _____

Output voltage _____V

Power range _____HP/KW

Control type _____

Braking type _____

3 Identify and trace the internal circuit of AC drive and get it approved by the instructor.

4 Check the switch /MCB , cables and fuse - wire rating and match with motor rating.

5 Draw the connection diagram of ICTP, drive, motor and get it approved by the instructor.

6 Connect the motor, AC drive, main switch as per approved diagram and get it checked the instructor. (Ref. Fig 1)

7 Connect double earth independently for the main switch, AC drive and the motor.

Improper connection of AC drive results shock and material damage.

TASK 2 : Connect, run the motor and setting the parameter of different speed

1 Select the suitable type of model AC drive.
2 Connect and wire the AC drive input power supply with terminals R/L1, S/L2, T/L3, when the output terminals U/T1, V/T2, W/T3, are connected to the motor. (Fig.1)
3 Switch ON the power supply main.
4 Press RUN/STOP button. The motor will run.
(Ref. Fig 1 Measure the speed of motor by using the Tachometer and record it_____RPM.
5 Increase and decrease the frequency and check the change in speed of the motor.
6 Press ‘STOP’ button and turn ‘OFF’ main power supply to disconnect the supply.
Improper connection of AC drive results shock and material damage.
TASK 3 : Reverse the direction of rotation in AC motor by setting in AC drive
1 Switch ON the power supply main.
2 Press key RUN/STOP button (Ref.Fig 2). The motor will run in forward direction.
3 Set the parameter for reverse direction. (Ref.Fig 2)
4 Press RUN / STOP, button key, The motor will run in reverse direction.
5 Press the STOP button to stop the motor.
Improper connection of AC drive results shock and material damage.
The motor will run as you press the key and will stop as you leave the key
6 Turn ‘off’ the power supply and disconnect the drive.
Do not run the motor at low speed for longer time. Because the motor cooling will not be effective due to low fan speed. So motor will heat up.
The programming procedure /keys may differ according to the make model of the drive in your institute. Refer to the drive instruction manual and take help of your instructor.

Construct and test a universal motor speed controller using SCR
Objectives : At the end of this exercise you shall be able to
• wire an universal motor speed controller circuit on PCB and test it
• assemble the wired PCB along with POT and socket in a gang box and test
• test the speed controller with lamp, fan, electric drilling machine
• check possible minimum and maximum speed adjustment using contact type tachometer.
Requirements
Tools/Equipments/Instruments

• Trainees tool kit - 1 Set
• Electric hand drilling machine - 1 No.
• Contact type tachometer with - 1 No.
necessary attachments
• Wired lamp holder with lamp of 40W - 1 No.
or less (Test Lamp)
• Main operated table fan of any make - 1 No.
Materials/Components
• Resistors
– R1 = 10K.5W - 1 No.
– R2 = 470 ohms ± 5%, 1/4W - 1 No.
– R3 & R4 = 1K ohms ± 5%, 1/4W - 2 Nos.
– Potentiometer (RV1) = 1K, 1W - 1 No.
• Capacitors
– C1 = 2U2, 63V - 1 No.
– C2 = 100 nf (Polyster) - 1 No.
• Semi-conductors
– SCR - C106D or equivalent or any - 1 No.
SCR of 400V and current rating
greater than 3 Amp
– Q1 BD135 or equivalent - 1 No.
– Q2 BD136 or equivalent - 1 No.
– (D1,D2) IN4004 - 2 Nos.
• Other items
– PC board code to be made as in Fig 2 - 1 No.
– 100 x 75 mm gang box used for
conduit wiring - 1 No.
– Hylum sheet 100 x 75mm x 3mm thick - 1 No.
– Self threading screw 3mm x 10mm for
fixing hylum sheet on gang box - 6 Nos.
– 3mm x 20mm screw and nut (to fix - 4 Nos.
PCB inside the gang box)
– Spacers 3mm x 10mm (to separate - 4 Nos.
PCB from gang box)
– 5Amps, 3 core cable (Mains cord) - 2 m
– 240V, 6 Amps flush type socket - 1 No.
– 240V, 6 Amps, flush type SP switch - 1 No.
– 240V, 6 Amps, 3 pin plug - 1 No.
– Knob suitable for 16 mm plastic - 1 No.
shaft pot
– Heat sink for SCR (suitable size) - 1 No.
– Terminal strip 3 way - 1 No.
– Flexible wire, 5 Amps, 240V (Red, - 0.5 m
Blue, Green) each
– Hookup wire - 1 m
– Resin core soldering lead - 20 cms
PROCEDURE
1 Prepare a PCB for the given dimensions (Fig 1). Check

the sizes of the components with the soldering position on the PCB. If necessary slightly alter the dimensions of the PCB track.

2 Check the PCB tracks and clean PCB.

3 Test the components to confirm its working condition.

4 Wire the speed controller circuit on the PCB referring to the circuit schematic in Fig 2 and the PCB layout diagram (Fig 3). Get the wired circuit checked by your instructor.

5 Make connections for the POT, switch, 5A flush type socket, mains 3 core cable mains 3-pin top with the wired circuit on PCB by using suitable wires. Get the wiring checked by your instructor.

The wire connections are made is to test the wired speed controller circuit before assembling them in the gang box as in Fig 3. Therefore keep sufficient wire lengths in all connections made for the purpose of safety and ease of testing.

6 Test the working of wired circuit by connecting a test lamp load at the output of the speed controller circuit. Check the lamp glow bringing the two extreme positions of the speed.

If the lamp brightness is not varying , vary the position in the wired circuit/connections.

7 Test the speed controller usin

st the universal motor speed controller unit for its range of speed control by connecting an electric drill gun as load and measuring the speed of the gun at minimum, middle and maximum positions of the speed control POT.

11 Record the speed in Table 1. Use contact type tachometer to measure the speed of the electric drill gun at different speed control positions of the POT.

12 Get your work and recorded readings checked by your instructor.

Write the specifications of the wired speed controller on a paper and paste it at the back of the gang box in which the circuit is assembled.

13 Get it checked by your instructor.

The wired and tested universal motor speed controller can be effectively used for any practical applications. So preserve the project work made and use it whenever required.

Table 1

Position POT Speed in RPM

Minimum
Middle
Maximum

81
Electrical Exercise 4.4.183
Electrician - Inverter and UPS
Assemble circuits of voltage stabilizer and UPS
Objectives: At the end of this exercise you shall be able to
• construct voltage stabilizer circuit on PCB
• test the stabilizer for its low and high cut-off ranges
• assemble 'ON' line UPS with assembled PCB modules/circuit boards
• test the 'ON' line UPS for its function.
Requirements
Tools/Instruments
• Trainees tool kit - 1 No.
• Multimeter - 1 No.
• AC Voltmeter 0-300 V - 1 No.
• Variac 0-300V/1A - 1 No.
Materials
• General purpose PCB - 1 No
• Transistors - BC 147/157 - 2 Nos.
CL 100 - 2 Nos.
• Diode IN 4007 - 2 Nos.
• Zener diode 6V/0.5A - 1 No.
• LED, red & green - 1 No. each
• Inductor - 21 SWG
Ferrite core 100 turns - 2 Nos.
• Capacitor - 330 µFd/12V - 3 Nos.
100 µFd/12V - 4 Nos
• Resistors carbon film 1/2 W
1K5, 3K3, 1K - 2 Nos. each
560Ω, 100Ω - 2 Nos. each
4K7, 47K - 3 Nos. each
1K Pot - 1 No.
• Electronic relay - 170V - 270 V/6V - 2 Nos. each
moulded type : 3 pin
Buck - boost mains transformer
170V - 270V - 1 KVA
0-6 A, 0-6 V AC - 1 No.
• Assembled modules or PCBs of a
ON line UPS - 1 Set
• Incandescent lamps fitted in
pendent holders - 1 No.
• Connecting wires/cables - as reqd.
• Solder; flux etc. - as reqd.

PROCEDURE

TASK 1: Construct voltage stabilizer circuit on PCB

Finish the wiring and clean the PCB; check the wiring for its correctness.

4 Connect the transformer input wires to the Variac for testing the circuit. Connect the incandescent lamp in the output of stabilizer. (Fig 2)

5 Switch ‘ON’ the supply to Variac and slowly increase the voltage till normal LED glow and output lamp glow.

6 Switch ‘OFF’, remove the lamp and connect the voltmeters. Do not change the variac position.

7 Switch ‘ON’ the supply and note down the voltage in Table 1.

8 Test the bulk-boost action by increasing and decreasing of Variac voltage increase the variac voltage.

9 Check the voltmeter, starts to show increase in voltage initially; but drops to normal voltage. Note down both the voltage; Voltage in output and Voltage at Variac terminals. Record in the Table 1.

10 Reduce the voltage of Variac and note the voltmeter reading. The voltmeter voltage will decrease but regains its normal position.

11 Note this time voltage : Voltage at output and variac terminal voltage in the Table 1.

If the voltage is not changing when changing variac volt ; consult your instructor.

12 Remove all connections and get your voltage readings approved by your instructor.

Table 1

Sl. No.	Variac voltage position	Variac terminal voltage (Volt)	Output voltage (Volt)
1	Variac knob in Middle Position		
2	Increase from Middle Position		
3	Decrease from Middle Position		

TASK 2: Assemble of ‘ON’ line UPS using wired PCB modules

1 Refer the block diagram in Fig 2 and arrange the PCB wired modules.

2 Wire the PCB modules as per the block diagram in Fig 2 and check the sequence as per the Fig 3.

3 Connect the charged battery without shorting the battery terminals. Connect one single pole switches initially with battery circuit.

4 Connect the input to EMI filter. Check for any circuit problems. Switch ‘ON’ the circuit 240V AC. Check the output with Voltmeters. Record the meter reading in Table 2.

Fig 2

If it is not indicating any voltage and consult with your Instructor.

5 Switch ‘ON’ the battery. Check the voltage in the output and record the reading in Table 2.

6 Switch ‘OFF’ the Mains 240V and check the voltage in output, record the voltage in Table 2.
If no voltage consult with your instructor.

7 Connect the incandescent lamp in the output. Repeat steps 4 to 6.

8 Note the lamp brighten while input supply 220V. Switched ‘ON’ & ‘OFF’.
If lamp is not glowing or dim consult with your Instructor.

9 Get your readings approved by your instructor.

Table 2

Sl. No.	Input supply voltage (Volt)	Output voltage
1	‘ON’	
2	‘OFF’	

Electrical Exercise 4.4.184
Electrician - Inverter and UPS

Prepare an emergency light

Objectives: At the end of this exercise you shall be able to
- assemble the components on the PCB and construct charging circuit for battery
- assemble inverter circuit for emergency light
- assemble charging circuit and inverter circuit for emergency light.

Requirements

Tools/ Instruments
- Soldering iron 10W, 240V - 1 No.
- Wire stripper 150mm - 1 No.
- Tweezer 150mm - 1 No.
- Insulated round nose plier 150mm - 1 No.
- Insulated wire cutter 150mm - 1 No.
- Multimeter - 1 No.

Materials
- Step down transformer centre tapped 240/7.5-0-7.5V, 2A - 1 No.
- Rectifier diode in 5402 - 3 Nos.
- Lead acid battery 6V, 10Ah, maintenance free type - 1 No.
- Toggle switch 2A, 240V SPST - 1 No.

• Toggle switch 2A, 240 DPST - 1 No.
• Relay 6V DC, 5A with one ‘NO’ and
one ‘NC’ - 1 No.
• Fuse unit with fuse 0.5A (glass type) - 1 No.
• Fuse unit with fuse 2.5A (glass type) - 1 No.
• LED holder 5mm - 2 Nos.
• LED 5mm red - 1 No.
• LED 5mm green - 1 No.

PROCEDURE

TASK 1 : Construct charging circuit for emergency light

8 Check the connection as per circuit diagram.
9 Switch ‘ON’ the AC supply for charging the battery.
10 Check the glow of red LED which is an indication for the presence of AC supply.
11 After charging the battery switch ‘OFF’ the AC supply, put ‘ON’ the lamp and observe the functioning of the emergency light and also check the indicator green LED is ‘ON’.

Do not allow the emergency light battery to discharge fully.

• Resistance 1K, 1/4W- 1 No.
• Resistance 2.2K, 5 W - 2 Nos.
• Resistance 2.2 Ω 1/4 W - 1 No.
• Capacitor 10 µF, 25V - 1 No.
• Capacitor 1000 µF, 25V - 1 No.
• Soldering flux - 10 gms
• Soft solder 60% lead and 40% Tin - 50 gms
• General purpose PCB
150mm x 100mm - 1 No.
• PVC insulated tinned copper cable
14/0.38 mm - as reqd.
• P.V.C. Insulation tape 20mm, 10m - 1 roll
• Screw type incandescent lamp 6V 15W - 1 No.
• Transistor 2N 3055 with the heat sink - 1 No.
• Resistance 50Ω, 5W - 1 No.
• Capacitor 2.2 µF, 250V - 1 No.
• Inverter transformer 6V, 20W - 1 No.
• Complete fluorescent tube light
fitting with 20W tube in suitable
sheet metal box - 1 Set
• S

ASK 2 : Construct inverter circuit for emergency light

1 Trace the circuit diagram of an emergency tube light circuit as per diagram. (Fig 2 and 3)
2 Identify the each component of the circuit.
3 Solder the components on PCB for making inverter circuit. (Fig 3)

Inverter circuit preferably to be assemble in a separate small PCB
4 Mark the inverter circuit board with charging circuit. (Fig 2)
5 Test the emergency light after connecting fluorescent tube light.
6 Fix permanently the charging unit, inverter and fluorescent tube suitably in a box/case.
7 Check the indicating LED Red and Green functioning correctly.
8 Get the work checked and approved by instructor.

Requirements

Tools/Instruments

- Trainees tool kit - 1 Set
- soldering iron 35W/250V - 1 No.
- De soldering gun 65W/250V - 1 No.
- Star screw driver set - 1 Set (set of 6 Nos)
- Ammeter 0-10 A M.C - 1 No.
- Voltmeter 0-50V M.C - 1 No.
- Digital multimeter (31/2 digits) - 1 No.

Equipments/Machinery
• Auto transformer 0-270 V-5A - 1 No.
• Step down transformer 240/40V, 300VA - 1 No.
• Charger transformer with centre tapping
6V-0-6V,500mA - 1 No.
• Sealed maintenance - 1 No.
Free battery 6V/120AH
• Relays double pole - 3 Nos.
Materials/Components
• PCB -115 -General purpose - 2 Nos.
• Push button switches - 2 Nos.
• Toggle switches 250V/6A - 2 Nos.
• Diodes 1N4002 - 4 Nos.
• Diodes for bridge 1N112 - 4 Nos.
• Capacitors -250mfd /12V - 1.No.
• Resistors,10Ω, 1W - 1 No.
• Pot 1.5Ω/10W - 1 No.
• Low voltage lamp 6.3V - 1 No.
• Fuse 250 mA - 3 Nos.
• Neon lamp - 1 No.
• Buzzer 250V - 1 No.
• Soldering flux and 60/40 solder - as reqd.
• Diode IN 5402 - 3 Nos.
• LED : Red and Green - 1 No.
• Transistor - 2N 3055 - 1 No.
• Resistor : 2.2Ω, 22Ω, 50Ω, - 1 No. each
1K (1 Watt) - 2 Nos.
• Electrolytic capacitors
1000 µfd/25V, 10 µfd, 25V -2Nos.each
• 2.2 µfd/250V - 1 No.
• Relay NC/No 6V - 1 No.
• Transformer 240V/7.5 - 0 - 75V, 2A - 1 No.
• Inverter transformer- iron core laminated
21 SWG - 25 turns,
29 SWG - 15 turns - Primary
36 SWG - 285 turns - Secondary - 1 No.
• Fuse 2.5A, 0.5A - 1 No. each
• SP Switches (Toggle - 6V) - 2 Nos.
PROCEDURE
TASK1 : Assemble the battery charging circuit
Electrical Exercise 4.4.185
Electrician - Inverter and UPS
Assemble circuits of battery charger and inverter
Objectives: At the end of this exercise you shall be able to
• assemble the battery charging circuit wired on PCB and test it
• construct and test inverter.
1 Select suitable PCB (wired PCB)and other components
2 Check all components ie. transformer, relays, battery

for their good condition
3 Construct the transformers relays, and other components on PCB. (Fig 1)
4 Connect the charger Transformer (X1)to the auto transformer (X2).
5 Connect the secondary of charger transformer (X1) to the full wave bridge rectifier which supplies rectified voltage to the battery under charge through ammeter, voltmeter and potentiometer.
Step down transformer (X3) keeps the cut off relay in energised condition when the main AC supply is cut off to the charger circuit. Relay (RL1) is used to cut off the AC main supply to the charger circuit.
6 Connect the pole (P1) of relay (RL1)to A.C main supply and connect pole (P2) is cut off circuit.
7 Connect the poles (P1 & P2) to normally open (N/O) pin, which will switch 'OFF' AC Main supply to the circuit.
8 Connect the test switch (S3) to check battery polarity.
Reset switch (S4) is used to reset the charger, when any fault occurs and the charger is cut off. The switch (S1) for ON/OFF.
9 Connect the ON/OFF switch (S1) to the input of AC main supply.
Normally a fully charged lead acid battery voltage 2.1 V/cell, During on charge ,and can be increased up to 2.7 V/cell .The voltage of a battery is multiple of the number of cells in that batteryConnect the diodes neon lamps, fuses, capacitor, resistor, buzzer, low voltage lamp in correct position as in the circuit.
11 Solder all PCB connection neatly and clean the PCB, without making any short circuit.
12 Set the auto transformer (X2) is in zero level position, before charging the battery.
13 Keep the switches S1,S2 & S5 on open position .
14 Connect the battery to the charger output terminal (positive terminal to the battery positive pole and negative terminal to the battery negative pole)and close the switch S3.
15 Check the readings in voltmeter which is connected through diode D9 and switch S3.
If the battery is connected in wrong/reverse polarity, then the diode will block the battery voltage and no reading in voltmeter. Correct the battery polarity by charging the connection to read the volt meter.

16 Close the main ON/OFF switch (S1) by keeping the zero position of an autotransformer (X2) and neon lamp (N1) and Lamp (L1) will indicate ‘ON’.
17 Vary the setting of Auto transformer slowly from zero position until the voltmeter shows the reading nearer to the voltage of battery to be charged.
18 Switch ‘ON’ the charging switch (S2) and increase the voltage by varying auto transformer till, the required charging current (5 Amp) is displayed by the ammeter.
19 Leave the charger on to charge the battery to the required level.
If the battery is fully charged automatic cut-off circuit will switch ‘OFF’ the supply to the battery, and automatically switch ‘OFF’ the charging current which flows through potentiometer VR1 , to cut off relay RL1.
When the battery is fully charged the current through the potentiometer increases and relay RL1 is energised through diode D7 and D8, and the pole of relay RL1 (ca) is connected to N/O contact which will cut off main A.C supply to auto transformer X2 and switch on the error indicator buzzer and the warning neon ‘N2’ lamp.
20 Switch ‘OFF’ the buzzer by the switch (S5).

The error indicator neon lamp (N2) and the buzzer stays on till the charger is reset.
21 Press the reset switch (S4), only, if the process to be continued once again.
If the reset switch is pressed without correcting the problem which activated the cut off and again it will operate instantly. To reset the charger, the reset button (S4) to be pressed for about one second, only to let the capacitor C1, discharge.
The following precautions to be followed when charging the battery.
1 The level of electrolyte should be about 1.2 cm above the plates.
2 Add distilled water to electrolyte if the level of electrolyte is low (acid should not be added to the electrolyte).
3 Charge the battery continuously unless the battery temp. exceeds 37° C stop charging for some time to cool down the battery.

TASK 3: Construct and test inverter circuit
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.4.185
The inverter made for emergency light
(Ex. No.4.4.184) can be utilised for this exercise.
1 Collect the inverter circuit assembled in the emergency light. (Fig 4) (Ex. No.4.4.184)
2 Remove the tube light and make the terminals free.
3 Connect the terminals of mains to the supply and switch 'ON'.
4 CheckthecorrespondingLED'sareglowingandmeasure the output voltage.
5 Connect the inverter circuit with supply. Disconnect the main AC supply and test the output of inverter by connecting load and note the performance.

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6 Report your instructor and get his approval.
Check the backup time of the inverter and verify the same with manufacture's manual.

Electrical Exercise 4.4.186
Electrician - Inverter and UPS
Test analyse, defects and repair voltage stabilizer, emergency light and UPS
Objectives: At the end of this exercise you shall be able to
• analyse the defect and repair voltage stabilizer
• repair and maintenance of emergency light
• analyse the fault and repair the defects in UPSls/Instruments
• Trainees Tool kit - 1 Set
• Connector screw driver set - 1 Set
• Line /Neon tester 500 V - 1 No.
• Soldering iron 35 W/250V - 1 No.
• Desoldering gun - 1 No.
• Multimeter (analog (or) digital) - 1 No.
• Clamp on meter - 1 No.
Equipments
• Common UPS 625 VA/12 V - 1 No.
• Sealed lead acid battery with operation manual (maintenance free battery)
12 V/120AH - 1 No.
• CRO 20 MHz/dual trace - 1 No.
• Assembled circuit of voltage stabilizer in Ex. No. 4.4.183
• Assembled circuit of emergency light in Ex. No. 4.4.184
• Assembled circuit of 'ON Line' UPS in Ex. No. 4.4.183
Materials/Components

• Spare components - as reqd.
• Solder 60/40 - as reqd.
• Soldering flux - as reqd.
• Connecting wires - as reqd.

PROCEDURE

TASK 1: Analyse the fault and repair of voltage stabilizer with the help of a Service Flow Sequence (SFS)

1 Check the circuit carefully before connecting the supply for any short circuit in the components/parts in the stabilizer.

2 Connect the main supply cable into ohm meter and check the resistance by switch ‘ON’ the circuit (note to be connect with AC mains)

If it shows ‘0’ resistance, it indicates a dead short. Consult your instructor.

3 Check for any open circuit visually or by ohm meter after testing for short circuit.

If the meter shows infinity i.e. open circuit.

Otherwise, if it is a healthy circuit it will show some resistance reading.

4 Analyze the status of the circuit by the meters reading.

5 If the stabilizer is without short circuit fault, connect it to the supply mains and switch ‘ON’. Check the

TASK 2: Repair and maintenance of emergency light with the help of trouble shooting sequence block

1 Steps 1 to 5 on as same as follow in Task 1 . Refer the service flow sequence diagram (Fig 2) and solve it. There may be single fault or multi fault involving more components. A visual check will help in to find burning of components, dry soldering, loose connection, etc. A careful visual check is very much essential.

TASK 3 : Test UPS and identify the faults and rectify

1 Read and interpret the name plate details of the given UPS

Type of UPS.....ON line/OFF line

Model .....

Power rating .....VA

Change over time .....m sec

Battery rating .....

Back up time .....Hours

2 Switch ‘ON’ the UPS, with UPS. ‘Plugged in’

3 Press and hold the ON/OFF /test /silence button for more than one second until “Line normal ‘LED green lights up. (i.e U.P.S .’ON’ and ready for use)

If green LED does not light up, the possible causes may be (i) button not pressed (or) pressed to short (ii) voltage of battery less than 10V (iii) PCB - failure and (iv) load may be less than 20 W at battery mode.

4 Identify the problem by self testing UPS., and rectify this fault by referring the trouble shoot sequence block diagram (Fig 3)

5 To switch ‘OFF’ the UPS press and hold the ON/OFF/ test/ silence button for more than 3 seconds until the “Line normal” or “backup” LED ‘OFF’.

6 Check the condition of switch, (or) back up LED (yellow LED) (or) press the switch for more than 3 seconds and rectify the problem, if the UPS not switched ‘OFF’.

To de-energise the UPS properly in emergency, the right way is to switch ‘OFF’ the output switch to ‘OFF’ position and disconnect the power cord from the main supply.

7 Press the ON/OFF/test/silence switch, more than 3 seconds, to switch ‘OFF’ the UPS and battery.

8 Check the back up (LED yellow).

Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.4.186

symptoms of the unit, and record the symptoms.

Analyze the fault with the help of service flow sequence.

If the yellow LED (back up) lights ‘OFF’, the UPS and battery is on ‘OFF’ position. If the back LED is not ‘OFF’, it indicates UPS always at battery mode. The causes for this fault may in power cord, fuse or up normal voltage.

9 Check the condition of power cord, A.C fuse, abnormal voltage and PCB.

10 Rectify problem by referring the trouble shooting sequence block diagram (Fig 4)

Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.4.186

11 Press the ON/OFF/TEST silence button less than one second, when A.C mains supply is available observe the operation UPS

If the UPS operates on load on battery mode, then battery LED lights up, it indicates UPS is in ‘ON’ line operation.

If the UPS does not operate on load on battery mode and immediately returns to ‘ON’ line

operation and lights up the RED-LED ,It

Recharge the battery immediately for atleast four hours.
13 Check and test UPS with recharged battery and rectify the fault by referring Fig 5,Trouble shooting sequence block diagram.
If the “replace battery” (red LED) is still on, replace the battery.
14 Press the ON/OFF/test/silence button for less than 1 sec in ‘Backup’ mode ,observe the audible alarm, It should be ‘silence.
If does not function under ‘Low battery (or) over load conditions.
15 Check the beeping alarm ,when pressing the silence button to stop the operation of UPS.
If it is stopped in back up mode it indicates UPS is in normal . But, If the beep sound alarms continuing, It indicates that UPS is over loaded.
16 Press the button (ON/OFF)during alarms to stop the beeping when yellow LED (backup) lights up.
17 Check for the maximum connected load to UPS and rectify this fault by disconnect the excess until the beep alarm is not available.
TASK 4 : Replacement of battery
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.4.186
8 Remove the battery from the unit easily.
Cautions:
• Do not dispose of battery in fire
• Do not attempt to open the battery
• Use tools with insulated handles
• Remove watches rings etc while charging the battery
9 Place the new battery in the same position (or) direction as the old one.
10 Reconnect the leads (ie) read lead to positive (+ve) position and black lead negative (-ve)position.
11 Reconnect the equipment properly by following the steps 6,5 and 3 (in that order)
12 Check the unit for its good condition and performance.
Follow the instruction and procedure below for easy battery replacement
1 Unplug unit from AC power source and disconnect all connected equipments /load
2 Disconnect AC power cord from UPS unit
3 Turn the unit upside down and unscrew the 4 screws

on top of the battery.
4 Keep the screws in a safe place for re assembling
5 Turn the entire unit right side up, by holding the top firmly
6 Lift top cover off and place to the side.
The connection and electronics components will be exposed. Do not touch an inner components when changing the battery.
7 Disconnect and remove the two leads (red & black)from the battery.

Electrical Exercise 4.4.187
Electrician - Inverter and UPS
Maintain service and troubleshoot battery charger and inverter
Objectives: At the end of this exercise you shall be able to
• carryout service and troubleshoot a battery charger
• troubleshoot and repair a inverter.
Requirements
Tools/Equipments
• Trainees kit - 1 No.
• Multimeter - 1 No.
Material
• Collect the circuits already constructed in Ex.No. 4.4.185
PROCEDURE
TASK 1: Service and troubleshoot of battery charger
1 Trace the battery charger circuit m

Check the fuse provided in the fuse carrier. If the voltage is not available.
4 Test the voltage output at the bridge rectifier output with multimeter.
5 Check the conditions of bridge rectifies diodes if found defective replace. If no voltage available.
6 Check the AC input to Bridge network. If the diodes are OK.
7 Check the relay contacts and; ensure supply is available at primary of the auto transformer. If the AC is not available
8 Check the charging control circuit for normal working after the charging circuit is repaired.
9 Check that auto cut-off of AC Mains is ‘OFF’ the battery is fully charged.
10 Checkthediodeconnectedtopotentiometer and voltage at relay terminals, If auto cut-off is not working or

functioning, and if the voltage is present at relay terminal (pole) Auto cut-off is OK.
11 Check the conditions of the battery, fully charged battery will show DC Voltage in no load about 20% more than the rated voltage.
Do not allow the battery Voltage (no-load) drop below 70% of the rated voltage. If it is so revival of the battery is difficult.
12 Check while charging battery; ensure that it is topped-up with distilled water and caps are removed for easy gaseous out from the cells.
13 Complete the work and show to your instructor for approval.
TASK 2: Service and troubleshoot of inverter circuit
3 Remove the battery connect to AC Voltage check the inverter output with mains 'ON'.
4 Check the continuity of inverter transformer primary and secondary windings. If then is no output.
5 Check the transistor 2N3055 and the base supply. If the transformer is OK,
6 Check the fuse provided with NC of relay and check the conditions of relay contacts.
7 Check the rectifier diodes and bleeder resistor connections secondary to the Mains transformer.
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.4.187
1 Trace the circuit made in Ex. No.4.4.185 (Inverter circuit) and locate the Active Components. (Fig 2)
2 Carry out short circuit and open circuit test.
8 Check the mains transformer primary and secondary windings. Check the main fuse.
9 Once the repair is completed check the output voltage without battery connections.
10 Connect the charged battery if output is available and operate it and ensure its working. Maintenance of battery is explained in the Task 1 and follow the same.
11 Complete the work and show to your instructor for approval.
Electrician - Inverter and UPS
Install an inverter with battery and connect it in domestic wiring for operation
Objectives: At the end of this exercise you shall be able to
• select the proper rating of inverter to install
• select suitable place for the inverter in the house
• select a correct rating of battery and the place to keep with inverter
• install the inverter and make connection to the load
• test the inverter for its good performance in 'OFF' and 'ON' supply mai

Requirent

ools/Instruments
• Trainees kit - 1 Set
• Portable electric drilling machine 6mm - 1 No
• Star head screw driver set (set of 6mm) - 1 No.
• Rawl jumper No.8 - 1 No.
• Cutting plier 150mm - 1 No.
• D.E spanner set 6mm-25mm - 1 Set
• Ballpein hammer 0.75 kg - 1 No
• Single phase energy meter 250V/15A - 1 No
• Multi pin socket 3/5 pin 250V/6A - 1 No.
Equipments/Machinery
• 200W/250V/6A -inverter - 1 No.
• Battery 12V/120AH - 1 No.
Materials/Components
• 4 way MCB -20A - 1 No.
• 1.5mm2 P.V.C. copper (1/18)wires - as reqd.
• Auto wires (stranded) - as reqd.
• I.C.D.P switch 16A/250V - 1 No.
• 4 way MCB/ICDP20 A switch - 1 No
• Power socket 250 V/16A - 1 No
• Multi pin wall socket 250V/6A - 1 No
(2 in one)with switch
• Grease/VaselinePROCEDURE
TASK 1: Select, install inverter with battery to connect in domestic wiring

Connect the ON/OFF switch on the wall panel from
the phase output pin of inverter output socket (Fig 1)
12 Connect one common Neutral line of both inverter output
and mains AC supply.
13 Connect only one wire for the phase line from the inverter
output socket to the switches.
14 Give connection to one bulb, one fan (A) and 2 pin
socket only to the inverter output as in Fig 1.
15 Connect the other devices in the room i.e the tube
light, fan (B) and 3 pin socket directly to the mains AC
line.
Low wattage load only to be connected on the
two pin socket during the power ‘OFF’ time.
Heavy load should not be connected to this
socket., such as heater, geyser, motors in HP
etc.
16 Show the connection and get it approved by your
instructor.

17 Check the operation of inverter during power ‘OFF’ and then power returns.

If the main supply is ‘ON’ the load connected to the inverter will get the main AC supply and the other devices which are directly connected to the mains AC supply will also work on the main supply. (Fig 2a)

During power shut down, the devices which are directly connected to the mains AC will stop functioning and the devices connected to the inverter will keep on working on the inverter output . when the mains AC supply returns the inverter will again connect the load to its output. (Fig 2b)

Electrical Exercise 4.5.189

Electrician - Power Generation and Substation

Draw layout of thermal power plant and identify function of different layout element

Objectives : At the end of this exercise you shall be able to

• visit the thermal power plant and identify the various stages in the plant
• interpret the function of each stages of thermal power plant
• prepare and draw the schematic diagram of thermal power plant.

Requirements

Materials

• Drawing sheet - 1 No.
• Pencil (HB) - 1 No.
• Eraser - 1 No.
• Scale -300mm - 1 No.

PROCEDURE

Instructor may take the trainees to a nearest thermal power plant to visit the various stages of the power station and explain the functions of each st

isit the stages of a thermal power plant i.e.

a. Coal and ash handling arrangement
b. Steam generating plant
c. Steam turbine
d. Alternator
e. Feed water supply
f. Cooling arrangement

2 Identify the following constituents of a steam generating plant and write down their functions in Table 1.

Table 1

Constituents Type Function
a Boiler
b Super heater
c Economizer
d Air pre-heater
e Turbine
f Condenser
g Cooling tower
h Water treatment
chamber
3 Note down the details of the steam turbine and enter it in the diary.
4 Trace the various parts of alternator and note down the name plate details in Table 2.
Table 2
No.of phase _____ Single / three
Capacity _____ KVA / MVA
Speed _____ RPM
Output voltage _____ Volt
Current _____ Amp.
Frequency _____ Hz
Excitation current _____ Amp.
Sl.No_____
Year of Manufacturing_____
Model No _____
5 Draw the schematic diagram of thermal power station you visited in your record and get checked by your instructor.
Fig 1 is the model schematic diagram of a thermal plant given for general guidance to trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.
6 Note down the main stepup transformer specification and the type of cooling arrangements.

Electrician - Power Generation and Substation
Draw layout of hydel power plant and identify functions of different layout elements
Objectives : At the end of this exercise you shall be able to
• visit the various stages of hydro-electric plant
• interpret the functions of each hydro-electric plant
• prepare and draw the schematic diagram of hydro plant

aterials
• Drawing sheet - 1 No.
• Pencil - 1 No.
• Eraser - 1 No.
• Scale -300mm - 1 No.

PROCEDURE

Instructor may take the trainees to a nearest hydro-electric power station to visit the various stages of
the power station and explain the functions of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations
pertaining to the power plantPROCEDURE
Instructor may take the trainees to a nearest hydro-electric power station to visit the various stages of
the power station and explain the functions of each stage.
Before entering the power station the instructor should explain to the trainees all the safety regulations
pertaining to the power plant.

1 Visit the stages of a hydro-electric power plant i.e.(1) Hydraulic structures (2) Water turbines (3) Electrical equipments.

2 Identify the following stages of a hydro-electric plant and write down their functions in Table 1.

Table 1

Constituents	Type	Function
a Dam		
b Spill ways		
c Head works		
d Surge tank		
e Pen stocks		
f Tail race		
g Draft tube		
h Turbine		

3 Note down the speed of the water turbine and other details and enter it in the diary.

4 Trace the various parts of alternator and note down the name plate details in Table 2.

Table 2

No.of phase _____ Single / three
Capacity _____ KVA / MVA
Speed _____ RPM
Output voltage _____ Volt
Current _____ Amp.
Frequency _____ Hz
Excitation current _____ Amp.
Sl.No_____

Year of Manufacturing_____
Model No _____
5 Draw the schematic arrangement of a hydro-electric power station in your record and get checked by your instructor.
6 Note down the main step-up transformer specifications and the type of cooling arrangements.
7 Ensure that the cooling arrangement of power transformer, is water cooling or any other types.
8 Note the transmitting voltage range and the no. of transmission lines.

9 Note down the total installed capacity of the power station and maximum number of turbains working together at peak load hours.
10 Show your observation to your instructor.
Fig 1 is the model schematic diagram of hydro electric plant given for general guidance of trainees. The trainees have to prepare andElectrical Exercise 4.5.191
Electrician - Power Generation and Substation
Visit to transmission/distribution substation
Objectives: At the end of this exercise you shall be able to
• visit and trace the transmission and distribution line of substation
• identify the equipments in sequential stages of distribution substation
• prepare the layout and draw the single line diagram of the transmission and distribution substation
• visit and trace the transmission and distribution line of major substation.
Requirements
Tools/Equipment /Material
• Drawing sheet - 1 No.
• Pencil (HB) - 1 No.
PROCEDURE
The instructor may take the trainees to the nearest transmission /distribution main substation, and explain the name of the equipments, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.
1 Visit the transmission and distribution main substation.
2 Identify the sequential stages of transmission/ distribution substations.
3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT & PT etc, from the generator to the consumer points in sequence of transmission and distribution substation.
4 Note down the earthing system. The major substation provided with system earthing. Note the different values

of earth resistance displayed in the earth pit. Note down which equipment/installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions)

Table 1

Sl.No	Name of the equipments	Specification	Function
1			
2			
3			
4			
5			
6			
7			
8			

• Eraser - 1 No.
• Scale-300mm - 1 No.

6 Locate the places of equipments and draw the single line diagram of transmission and distribution substation, which you have visited.
It may be like the diagrams (Fig 1, 2, 3 and 4) given for your guidance. Refer related theory of this exercise also.

7 Get it checked with your instructor.

Electrical Exercise 4.5.192
Electrician - Power Generation and Substation
Draw actual circuit diagram of substation visited and indicate various components

Objectives: At the end of this exercise you shall be able to
• visit of substation and note down the various components
• draw the actual circuit diagram of substation with components.

Requirements
Materials
• Drawing sheet - 1 No.
• Pencil HB - 1 No.
• Eraser - 1 No.
• Scale -300mm - 1 No.

PROCEDURE
1 Visit the substation which is nearer to your institute with your instructor and note the various components installed as below.
• Incoming protection devices and their installations.
• Transformer specification - voltage rating capacity cooling method, earthing, HT and LT terminal connections.

• Installation of CTs and PTs and their connections.
• Installation of over voltage, under voltage, over current, earth fault relays and their protections - earthing - etc.
• Position of isolators, earth switches, feeders cable terminations and lights arrestors etc.
• Number of earth pits and their resistance values- periodical maintenance and testing procedure.
• The load distribution method adopted in substation to customers.
• Methods followed in substation to meet maximum demand and monitoring.
• Substation maintenance chart and methods to carryout maintenance without effecting power shut down totally.
• Any other points noticed or learned in the substation.

2 Draw the circuit diagram of substation, which actually you visited and draw the layout diagram of substation with various components.

Refer the drawing illustrated in previous Exercise 4.5.191 (Fig 4) for your reference.

3 Get it checked with your instructor.

Electrical Exercise 4.5.193

Electrician - Power Generation and Substation

Prepare layout plan and identify different elements of solar power system

Objectives : At the end of this exercise you shall be able to

• visit and interpret the details of solar power plant
• trace and identify the components used in solar plant and write t

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Electrical Exercise 4.5.193

Electrician - Power Generation and Substation

Prepare layout plan and identify different elements of solar power system

Objectives : At the end of this exercise you shall be able to

• visit and interpret the details of solar power plant
• trace and identify the components used in solar plant and write their functions
• prepare and draw the schematic diagram of solar power plant.

PROCEDURE

Instructor may take the trainees to the nearest solar power plant to visit the various stages of power station and explain the function of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the solar plant and note the details of the plant.

i Capacity of the plant _____ KW / MW

ii Output voltage _____KV
iii Permitted Maximum Load Circuit _____ Amp.
2 Trace and locate the components used in that solar plant.
3 Note down their functions as in Table 1

Table 1

Sl.No.	Name of the components	Functions/ specifications
1	Total solar panel area	
2	Method of mounting panels	
3	Controller circuits	
4	Battery system installed	
5	DC/AC Inverter Capacity & Voltage ratings	
6	Distribution panel to grid connections	

4 Note down the daily average power output of the plant for distribution.
5 Note specification of solar panels - make, voltage ratings etc.
6 Note tracking systems method provided for maximum output.
7 Note protection of cells from natural calamities.
8 Note installed cells whether in ground level or elevated.
9 Draw the schematic diagram of solar power plant as per the guidance. (Fig 1)
10 Get your work checked by instructor.

Fig 1 is the model schematic diagram of solar power plant given for the general guidance of trainees. The trainees have to prepare and draw the schematic diagram of the solar power plant they visited.

Requirements

Materials

- Drawing sheet - 1 No.
- Pencil HB - 1 No.
- Eraser - 1 No.
- Scale -300mm - 1 No.

Electrical Exercise 4.5.194

Electrician - Power Generation and Substation

Prepare layout plan and identify different elements of wind power system

Objectives : At the end of this exercise you shall be able to

- visit and identify the various components used in wind power generation plant
- prepare and draw the scheamtic diagram of wind power plant.

Requirements

Materials

- Drawing sheet - 1 No.
- Pencil HB - 1 No.

PROCEDURE

Instructor may take the trainees to the nearest wind power plant to visit the various stages of power station and explain the function of each stage.

Before entering the power station the instructor should explain to the trainees all the safety regulations pertaining to the power plant.

1 Visit the wind mill power plant, and note the details of the plant.

i Capacity of the plant _____ KW / MW

ii Output voltage _____KV

iii Maximum load Current_____ Amp.

2 Trace and identify the equipments/parts used in this wind mill power plant.

3 Write the names of the equipments and their functions in Table 1.

Table 1

Sl.No.	Name of the equipments/parts	Specification Functions
1	No. of wind blades _____	
2	Gear box _____	
3	Generator _____	
4	Exciter _____	
5	Turbine controller _____	
6	Rectifier Unit (RU) _____	
7	Line Converter Unit (LCU) _____	
8	High voltage transformer _____	
9	Internal Supply Unit (ISU) _____	
10	Chopper _____	
11	Wind turbine _____	
12	Grid _____	

4 Note down the daily average power output of the plant.

5 Note down the minimum rpm of turbine to maintain the rated voltage.

6 Note down the chopper/circuit characteristics and its importance in turbine controller.

7 Note down the protection provided from natural calamities.

8 Prepare and draw the schematic diagram of wind power station in your diary and get checked by the instructor.

Fig 1 is the model scheamtic diagram of wind power station given for the general guidance of trainees. The trainees have to prepare and draw the schematic diagram of the plant they visited.

• Eraser

lectrical Exercise 4.5.195
Electrician - Power Generation and Substation
Assemble and connect solar panel for illumination
Objectives: At the end of this exercise you shall be able to
• calculate the total no. of cells required to make series parallel combination for one panel
• fix the 4 Nos of LED lamp 12V/3W at required position in the lamp
• Wire the circuit from panel to light in the lab
• fix the panel board with control and protection devices to illuminate the lab
• assemble and install solar panel at mid clamp and roof top.
Requirements
Tools/Equipments
• Trainees kit - 1 No.
• Multimeter - 1 No.
• Power drilling/hammering machine
with suitable drill bits - 1 Set.
• Solar panel - 1 No.
Material
• Solar cells 0.45 V/57mt. 125mW/cm2 - 540 cells
• Connecting wires 1 sq.mm PVC cable - as reqd.
• Gang box with one switch
(F/type one way) 250V/5A - 4 Nos.
• Panel frame suitable to
fix the wired solar cells - 4 Nos.
• LED lamp with shad and reflector
12V/3W - 4 Nos.
• Fixing screws, wiring accessories - as reqd.
• Base pipe - as reqd.
• Contact pipe - as reqd.
• Supporting pipe - as reqd.
• Rail splice - as reqd.
• Rail - as reqd.
• Rail contract AC - as reqd.
• End clamp - as reqd.
• Mid clamp - as reqd.
• M8x25mm screws - as reqd.
• Bolt and nuts - as reqd.
PROCEDURE
TASK 1 : Calculate the number of cells required to illuminate one panel
(Assume the lamp voltage is 12V and power 3W)
1 Determine the number of solar cells in series group.
No. of cells in series group = cellVolt/
voltagerequiredTotal
V45.0cell1 = and 57mA
45.0
V12

= = 27 cells.
27 x 0.45 = 12.15V considering line losses voltage of
0.15 V taken as extra (0.15V taken for line lines)
No. of series group required for the correct of 250mA
groupseriesoneinCurrent
lamponeforrequiredCurrent
=
(LED lamp requires 250 mA) = mA57
mA250
= 4.38 = 5 groups
Considering the line losses few cells one
connector for extra current.
TASK 2 : Assemble of solar panel and its installation
1 Collect solar cells and make the series connection.
(27 cells in series) on the panel board.
2 Prepare five nos of series connection and wire them for
parallel as shown in Fig 1.
3 Make four similar solar panels in total.
4 Locate the suitable places and fix it on root top where
sunlights are falling directly

TASK 3 : Fix lamps and gang box
1 Locate the lamp position and switch position as short
as possible from solar panel for all the four panels.
2 Wire the panel to gang box and the lamp neatly.
Wiring can be done in PVC conduit or PVC
casing and capping to give aesthetic look
3 Fix the lamp assembly and complete the wiring with
switch control.
4 Test the wiring for any short (or) open circuit fault.
5 Connect the wire to the panel terminals and measure
the voltage at lamp terminal.
6 Connectthelampandoperatetheswitchforillumination.
7 Report to your instructor for his approval.
TASK 3 : Assemble and install solar panel at mid clamp roof top
1 Select the roof without shading for the solar panel
installation.
2 Check that sure the direction of installation of the solar
panels receives more sun rays to mount the solar
panel.
Select an area of roof to install the solar panels
that gets the sun light rays as along as possible
all days.
The solar panels can either be mounted flush
on the roof or stand, or mounted at an angle
to maximize the position of accessibility to the
sun's direct rays.
3 Collect contract pipe with M8 x 25 contact base pipe.

(Fig 1)
4 Fix the contact support pipe and contact pipe with M8 x 25 screw. (Fig 2 & 3)
5 Take 2 fixed tile rack and position them with rail as in Fig 4.
6 Put one panel on the rack, use 2 end clamps to hold and fix it (Fig 5). (Attention end of rail distance must <25mm to 30mm).

Fig 7
INSTALLED SOLAR PANEL AT ROOF ELN45195J7
7 Install the modules an mid clamp and end clamp.
8 Install panel by fixing mid clamp between panels. (Fig 6)
9 Select the best/perfect angle for solar panels with the help of manual to produce the maximum power.
10 Drill the hole on the roof with the help of drilling machine.
11 Fix the frame with the help of screws and place the panel on frame. (Fig 7) 12 Get the work checked by the instructor.

Electrical Exercise 4.6.196
Electrician - Transmission and Distribution
Practice installation of insulators used in HT/LT lines for a given voltage range
Objectives: At the end of this exercise you shall be able to
• identify the type of HT/LT line insulators
• install the shackle type insulator on HT over head line
• install the pin type insulator on LT over head line.
Requirements
Tools/Instruments
• Insulated combination plier 200 mm - 1 No.
• DE spanner set 6mm to 25 mm - 1 Set.
• Adjustable spanner 6mm to 25 mm - 1 Set.
• Safety belt - 1 No.
• Wooden or nylon mallet 1/2 kg - 1 No.
• Ladder 6m long
• Jute rope of 25 mm dia and 15 m length - 1 No.
• Wire stretcher 25 mm - 1 No.
• Megger 500 V - 1 No.
Materials
• Shackle insulator, porcelain 1kV - 4 Nos.
• Pin insulator, porcelain 1kV - 2 Nos.

• Suspension insulator - 1 No.
• Strain insulator - 1 No.
• Ring insulator - 1 No.
• Stay/egg insulator - 1 No.
• Cotton waste - as reqd.
• Binding wire 14 SWG aluminium - as reqd.
• Scrap piece of ACSR conductor of
length 1m (for bow) - 3 pieces
• Sandpaper or emery sheet - as reqd.
• Flat aluminium tape - as reqd.
• Protective grease suitable to apply
over the ACSR line conductor - as reqd.
• Line accessories - as reqd.

PROCEDURE

TASK 1 : Identify the LT and HT types of insulators

1 Identify the LT and HT type line insnstall the shackle insulator in HT

Take shutdown if the nearest lines are
energised. Use a safety belt while working on
a pole.

Before starting the work check the ladder,
safety belt and all the connected accessories.

1 Fasten the safety belt, lay the ladder on the pole.

2 Release the conductor from the reel, measure the
actual span plus sag and binding. Keep two lengths of
conductor. (Length of span + 1ft. Sag)

3 Check the shackle insulator for its damage and select
a good one. (Clean and carbonize etc.)

4 Check the assembly of the shackle insulator for its
proper fitting.

5 Ask the helper to hold the ladder, climb up the ladder
with the guide rope and spanner set.

While working on the ladder, the ladder should
be held by a helper to avoid slipping.

6 Position yourself conveniently on the cross-arm, tie
the safety belt end to the cross-arm. Send one end of
guide rope to the helper and ask him to tie to the
shackle assembly and lift it to the top.

7 Fix the shackle insulator to the cross-arm by 'C'
clamps. (Fig 1)

8 Get the draw pulley from the ground and secure it on
the cross-arm. Interlace the rope through the pulley
and send the other end to the helper.

9 Ask the helper to properly tie the O.H. conductor to
the rope and lift the conductor to the cross- arm
position.

While lifting the conductor both the end conductors should be lifted at a time first, and then middle conductors to avoid the fitting of the cross-arm.

While typing, the conductor to the rope the helper should leave atleast 1 metre length of conductor free at the end from binding.

10 Twist the end portion of the conductor over the main line conductor. (Fig 2)

TASK 3 : Install the pin type insulator in LT

1 Climb the next pole following the previous procedure

2 Lift the conductor and keep it on the pin insulator. Ask the other helper to lift and stretch the conductor with wire stretcher.

3 Fix the pin insulator to the cross - arm of the existing pole.

If the span is less, there is no need to use a draw pulley, pulling with the help of a rope is sufficient.

4 Bind the pin insulators as per procedure.

The binding wire must be of the same metal as the line wire.

Binding should be mechanically strong.

5 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction.(Fig 3)

11 Bind the shackle insulators with the one fixed at the last cross - arm.

Ground clearance of overhead conductor should not be less than 4.572 m for low and medium voltage.

12 Get down from the pole after checking the binding.

Binding should be tight without any gap.

Alternatively the conductor can be placed in the side groove for binding the conductor with the pin insulator as in Fig 4.

6 Complete the binding by giving about 15 turns on both sides.

7 Cut the extra binding wire and round off the raised ends.

8 Repeat the procedure for the other pin insulator by the side of the same cross arm.

Check the bindings before getting down. No tool and wire should be left on the cross-arm.

9 Test by a Megger of 500 Volt for insulation between conductors and insulation resistance between conductors and earth.

Sl.No.	Measurement between	Insulation value
1	Insulation resistance between conductors	Megohm
2	Insulation resistance between first conductor and earth	Megohm
3	Insulation resistance between second conductor and earth	Megohm

The distribution lines shall be charged only when the megger test is satisfactory. It must be a minimum of 1M and above for medium voltage lines.

lectrical Exercise 4.6.197

Electrician - Transmission and Distribution

Draw single line diagram of transmission and distribution system

Objectives: At the end of this exercise you shall be able to

• visit and trace the transmission and distribution system

• identify the equipments in sequential stages of transmission and distribution system

• prepare the layout and draw the single line diagram of the transmission and distribution system.

Requirements

Tools/Equipment /Material

• Drawing sheet - 1 No.

• Pencil (HB) - 1 No.

PROCEDURE

The instructor may take the trainees to the nearest transmission and distribution line system and explain the name of the equipment, their specification and function also instruct the trainees to follow the safety regulation while visiting the substation.

1 Visit the transmission and distribution line system and power plant.

2 Identify the sequential stages of transmission and distribution line system.

3 Trace and identify the various equipments like transformers, feeders, circuit breakers, Isolator, CT and PT etc, from the generation to the consumer points in sequence of transmission and distribution system.

4 Note down the earthing system. Note the different values of earth resistance displayed in the earth pit. Note down which equipment and installation requires the least earth resistance value and irregular value. Identify the hollow conductors used for connection between feeders.

5 Note down their details in Table 1 (Name, Specification and functions) for transmission system and Table 2 for distribution system.

Table 1

Transmission system

SI.No Name of the equipment Specification Function
1
2
3
4
5
6
7
8
6 Locate the places of equipments and draw the single line diagram of transmission and distribution system. Which you have visited.
It may be like the diagram shown in Fig 1, 2.
Refer related theory of this exercise also.
• Eraser - 1 No.
• Scale-300mm - 1 No.

Table 2
Distribution line system
SI.No Name of the equipments Specification Function
1
2
3
4
5
6
7
8

Electrical Exercise 4.6.198
Electrician - Transmission and Distribution
Measure current carrying capacity of conductor for given power supply
Objectives: At the end of this exercise you shall be able to
• identify and select 3 different conductors i.e. copper, aluminium and alloy
• connect the circuit and measure the breaking current of the conductor.
Requirements
Tools/Instruments/Equipment
• Trainees tool kit - 1 No.
• Ammeter M.C. 0-10A - 1 No.
• Voltmeter M.C. 0-15V - 1 No.
• Rheostat 270Ω 2A - 1 No.
• Lead acid battery 12V 60AH - 1 No.
Material
• Wooden board with switch 16A 250V - 1 No.
• 32 SWG copper conductor,

aluminium conductor and alloy conductor - 10 cm
• Connecting wires 2.5 sq.mm copper - as reqd.

PROCEDURE

1 Select 32 SWG copper conductor, aluminium conductor and alloy conductor of 10 cm length each.
2 Connect it on the test board. (Fig 1)
3 Connect rheostat, ammeter voltmeter and battery. (Fig 1)
4 Keep rheostat at cold end (maximum resistance position) and switch 'ON' and note the ammeter and voltmeter readings and enter in the Table 1.
5 Move the rheostat at middle position and note down the ammeter and voltmeter readings and enter in Table 1.

At this stage the conductor may get heated up (or) it will show the system of heating.

6 Adjust further more the rheostat position to hot end (reduce the resistance) slowly keeping a watch on conductor it may brake now.
7 Observe if the conductor is not broken and increase further position of rheostat towards hot end till the conductor breaks and note down the corresponding meter readings in Table 1.
8 Note down this is the maximum current carry capacity of the conductor.

If the conductor is not broken, reduce the thickness of conductor (or) change the battery.

9 Connect the aluminium and alloy conductor separately and repeat the steps to find the maximum current capacity of the 2 to 9 conductors.
10 Tabulate all the readings and show to your instructor.
11 a Maximum current capacity of copper conductor is Amp
b Maximum current capacity of aluminium conductor

Electrical Exercise 4.6.199

Electrician - Transmission and Distribution

Fasten, jumper in pin, shackle and suspension type insulators

Objectives: At the end of this exercise you shall be able to

• select the pin type, shackle type and suspension type insulators
• fasten jumper in cross-arm of pole with pin insulator
• fasten the jumper in shackle type insulator
• fasten the jumper in suspension type insulator.

Requirements

Tools/Equipment /Material

• Insulated combination plier 200mm - 1 No.
• DE spanner set 6 to 25mm - 1 Set
• Adjustable spanner 25mm - 1 No.

• Wooden or nylon mallet 1/2kg - 1 No.
• Ladder 6m long - 1 No.
• Wire stripper 150mm - 1 No.

Material

• Suspension type insulator - 2 Nos.
• Shackle type insulator - 2 Nos.
• Pin type insulator - 2 Nos.
• Flat aluminium tape - as reqd.
• Binding wire 14 SWG aluminium - 5m
• ACSR conductor - as reqd.
• Safety belt - 1 No.
• Clamp - as reqd.
• Nut and bolt - as reqd.

PROCEDURE

TASK 1 : Fasten the jumper in pin insulator

1 Keep the ladder on the pole and ask the helper to hold the ladder. climb up the ladder with the guide rope and spanner set.

2 Fix the pin type insulator to the cross-arm of the existing pole.

3 Tape the neck of the pin insulator with flat aluminium tape.

4 Lift the Aluminium Contactor Steel Reinforced (ACSR) conductor and keep it in between pole and the pin insulator.

5 Lay the ACSR wire on the slot of the pin insulator and ask the other helper to stretch the conductor with a wire stripper.

6 Take the binding wire of about 2 metres length, leaving equal length on both sides. Bind two turns on the insulation (Fig 1a) around the neck of the pin insulator.

7 Make a knot of the binding wire with the free ends tightly. (Fig 1b)

Binding should have mechanical strength.

8 Bind the free ends of the binding conductor over the line conductor tightly in the opposite direction. (Fig 2)

Binding should be tighten without any gap.

Where deviation or bend comes the ACSR conductor bind on the neck of the pin insulator. (Fig 3)

9 Complete the binding by giving about 15 turns on both sides.

10 Cut the extra binding wire and round off the raised ends.

TASK 3 : Fasten Jumper in suspension type insulator

1 Keep the ladder on the pole and ask the helper to hold

the ladder. Climb up the ladder with the guide rope and spanner set.
2 Fix the suspension insulator to the cross-arm.
3 Ask the helper to properly lift the conductor to the cross-arm position.
4 Place the conductor in between two clamps.
5 Tight the bolt & nut of the clamp perfectly.
6 Bind the ACSR conductor with 14 SWG aluminium wire tightly Fig 6 in the suspension insulator.
Electrical : Electrician (NSQF LEVEL - 5) - Exercise 4.6.199
TASK 2 : Fasten jumper in shackle insulator
1 Keep the ladder on the pole and ask the helper to hold the ladder. Climb up the ladder with the guide rope and spanner set.
2 Fix the shackle insulator to the cross-arm with 'C' clamp.
3 Tape the ACSR conductor with flat aluminium tape where it touches the insulator.
4 Ask the helper to properly tie the O.H. conductor to the rope and lift the conductor to the cross-arm position.
While tying the conductor to the rope the helper should leave atleast 1 metre length of conductor free at the end for binding.
5 Insert the conductor around the groove of the insulator leaving half metre at the end. (Fig 4a & 4b)
6 Bind the ACSR conductor with 14 SWG aluminium binding wire tightly (Fig 5a) about 100 to 150 mm approximately.
7 Bend the end of the ACSR conductor in Fig 5(b). and complete the binding work .
Ground clearance of overhead conductor should not be less than 4.572 M for low and medium voltage.
7 Complete the work and report to your instructor.

Electrical Exercise 4.6.200
Electrician - Transmission and Distribution
Erect an overhead service line pole for single phase 240V distribution system in open space
Objectives: At the end of this exercise you shall be able to
• select the place to erect the pole
• select the type of pole to be erected
• fix the cross-arm on the pole
• dig the pit and erect the pole.
• M.S. angle iron cross-arm
50mm x 50mm x 6mm size suitable

for 240V supply line - 1 No.
• ‘C’ clamp M.S. size as required with
nuts, bolts and washers - 2 Sets.
• Country wood plank 2m long, 30cm
width 5cm thick - 1 No.
• Cement, sand, blue metal chips etc
as per the size of pit - as reqd.
• Stay insulator (egg insulator) - 2 Nos.
• Double screw stay tightener - 2 Nos.
• C.I. stay plate - 2 Nos.
• Stay rod - 2 Nos.
• H.D.G. steel wire (stay wire) 7/16 SWG - 16m
• 50 x 12mm size M.S. bolts and nuts
with washers - 2 Nos.
• Base plate for pole - 1 No.
• Casuarina pole of suitable height - 4 Nos.
• Wooden box of suitable size having
2 side openings for concrete pedestal - 1 No.
Requirements
Tools/Instruments
• D.E. spanner set 6mm to 32mm - 1 Set.
• Combination pliers 200mm - 1 No.
• Heavy duty screwdriver 300mm - 1 No.
• Safety belt to work on pole - 1 No.
• Crowbar 2m long 40mm dia - 1 No.
• Spade - 1 No.
• Shovel - 1 No.
• Plumb bob with thread - 1 No.
• Cotton or jute rope 15m long - 1 No.
• Hammer ballpein 500g - 1 No.
• Safety belt - 1 No.
• Bamboo ladder - 1 No.
• Draw pulley - 1 No.
• Aligning rod - 1 No.
• Metal ram - 1 No.
Materials
• Wooden/RCC/iron/tubular pole of 6m
length - 1 No.
PROCEDURE
1 Select the place for fixing the pole near the building
based on the span.
2 Select the type of pole to be erected. (Fig 1Dig a pit about 1/6th height of the pole having a
diameter of minimum 3 times that of the dia of the pole
bottom.
4 Prepare a mixture of concrete having a ratio 1:2:4 (one
part cement, two part coarse sand and four part 2 cm
blue metal chips) and pour the same in the bottom of

the pit to a height of 15cms.
5 Ram the concrete and allow it to settle for a minimum period of 48 hours.
6 Keep the base plate for the pole at the bottom of the pit.
7 Fix a vertical straight pole on the plumb line in the pit. Refer (Fig 2)
8 Bring the pole and place it near the pit so that the bottom of the pole is at the edge of the pit.
9 Insert the wooden plank (board) vertically at one side of the pit facing opposite to the bottom portion of the pole.

10 Fix the cross arms at the top of the pole below 30 cm from the top, with the help of 'C' clamps rigidly.
11 Tie the two ropes just below the cross arms. Ensure that the cross arm is in the required direction
12 Place the casuarina pole at a distance of 1/3 height of the top and also 1/3 height from the bottom of the pole.
13 Prepare concrete mixture in the ratio of 1:3:4 (cement, sand and 1 cm blue metal chips).
14 Lift the pole step by step with the help of a rope and casuarina pole (Fig 3) and place it on the pit exactly vertical.
15 Check the vertical position with the help of an aligning a rod and plumb bob.
16 Pour the concrete mixture around the pole inside the pit and then place the wooden box around the pole.
17 Pour the concrete mixture in the box to a height of 0.5m above the ground level. Ram the mixture properly.
18 Cure the cement concrete for about 48 hours.
19 Remove the wooden box and plaster the cement concrete above the ground surface to have a smooth finish.
20 Fix the stay rod to the ground at a distance so as to get 45° to 60° between ground level and stay wire should be placed in the opposite direction to the line.
21 Cut the stay wire into 2 pieces of equal length.
22 Fix one end of each piece of the stay wire to the strain insulator (egg insulator).
23 Fix the other end of the second piece of stay wire to the stay. Tighten using a thimble.
24 Fix the stay and tighten to the stay. Assuming the stay rod is fitted to the ground through a concrete structure which was sufficiently cured.
25 Tighten the stay tightener nut till there is no sag in the

stay.
After drawing the overhead lines the stay should be tightened to compensate the tension of the overhead lines and to keep the pole in the vertical position.

Electrical Exercise 4.6.201
Electrician - Transmission and Distribution
Practice on laying of domestic service line
Objectives: At the end of this exercise you shall be able to
• locate the nearest pole, specify and estimate the quantity of materials required
• prepare the GI pipe, bend in the form of a goose neck and install it in position
• prepare the support GI wire with (ring insulator as) separators and service cable
• draw the service cable and connect it to the energy meter
• connect the service cable to the overhead lines through an aerial fuse
• earth the service cable support wire at both ends.
Requirements
Tools/Instruments
• Electrician tool kit - 1 No.
• Pipe jumper 25 mm dia. 40 cm length - 1 No.
• Pipe wrench 50 mm - 1 No.
• Megger 500V - 1 No.
• Rawl plug tool No.10 with bit - 1 No.
• Hacksaw adjustable with blade 300 mm - 1 No.
• Safety belt - 1 No.
• Bamboo ladder 6 m. height - 1 No.
• GI die set with stock 15 to 40 mm - 1 set
Materials
• Earth clips 40 mm - 6 Nos.
• Twin core service cable weather- - 20 m proof or PVC sheathed insulated cable 2.5 sqmm., 250V grade
• GI wire 10 SWG - 30 m
• GI wire 12 SWG and 22 SWG - 15m each
• GI wire 7/3.15 mm size - 5 m
• Porcelain ring insulator - 70 Nos.
• GI pipe 40 mm - 3 m.
• GI bends 40 mm - 1 No.
• MS clamps 40 mm, 3mm thick - 4 Nos.
• Wood screws 40 mm No.8 - 8 Nos.
• Silver paint 200 ml. - 1 No.
• Stay insulator - 2 Nos.
• Bombay nails - 8 Nos.

• Cable glands (heads) - as reqd.
• Bricks - as reqd.
• Sand - as reqd.
• Cable compound - as reqd.
• Solder - as reqd.
• Clamps for fixing cable - as reqd.

PROCEDURE

Drawing a service line is the work of the staff of the electricity board. Some of the trainees may get
employment in state electricity board. When working on a service line it is utmost necessary to make a
shut down before connecting the service cable to the service line.

1 Locate the nearest electrical pole and measure the distance from the pole to the building to which the service line is to be drawn (Fig 1) . Enter the measured value in Table 1.

Care should be taken to see that the service cable does not cross the adjacent building area. In some cases an intermediate pipe structure may be needed to avoid crossing.

2 Identify whether the supply required for the house is single or 3-phase and enter it in Table 1.

3 Locate the position of the meter board and determine the height of GI pipe to be fixed for service connection. Refer to Fig 2, record the findings in the Table 1.

Preferably the entry height of the service cable of the GI Pipe should be at the height of the pole. If this is not possible due to the lower height of the house, arrange to fix the GI pipe at a maximum possible height.

4 Determine the length required for the goose neck bend and the thickness of the wall. Refer to Fig 2 and enter these particular in Table 1.

Table 1

Service connection measurements in metres for the supply of single/three phase

Distance between the pole and the GI pipe	Height of the entry point of the GI pipe	Length of the goose neck bend in mm	Wall thickness	Height of the meter board	Total length
D	H	P	T		L
					Length of the GI pipe H+P+T - (Length of bend)metres.
					Length of the GI wire as service line support wire. D+P+3 metres.

Length of service cable
Single phase = [(D+H+P+T+L) 2]
+ 10%
3-phase = [(D+H+P+T+L) 4]
+ 10%
5 Determine the length of the cable required from the inside wall to the meter terminals and enter the recorded measurements in Table 1. Calculate the required length of service cable and GI pipe from the above particulars and enter the values in Table 1.
6 Mark and cut two pieces of GI pipe of length L1 and L2. Refer to Fig 3.
7 Thread the GI pipe of length L1 and L2 at one end.
8 Bend one end of the longer GI pipe L1 to form the goose neck having a diameter equal to 12 times of the pipe diameter.
9 Make a hole in the wall with a pipe jumper such that the pipe when fitted is nearer to the energy meter terminals. The hole should not be less than two metres from the ground.
10 Fix the GI bend to the GI pipe. (Fig 3)
11 Pass the fish wire (GI wire of 20 SWG) through the assembled pipe.
12 Fix the GI pipe vertically to the wall using MS clamps. (Fig 3)
Use minimum one stay bow to the GI pipe in case the GI pipe has to be erected above the wall. Refer to (Fig 4a) and fix the other end of the stay bow to the eye bolt fixed to the roof.
13 Bind two numbers of the small ring insulators (separators) in the case of single phase supply, in one set by means of suitable GI wire of 20 SWG. (Fig 4b)

Normally a goose neck bend should have a diameter 12 times the diameter of the pipe.
Say for a 25mm pipe te ‘U’ clamp fixture should be sufficiently strong to withstand pull exerted by the weight of the service line and wind force.
17 Fix the other end of the support GI wire to the pole. (Fig 4a)
Use a ladder and wear a safety belt. Before climbing up the pole permission should be obtained from the electricity board and a shut down taken for safety.
18 Draw the service cables through the GI pipe by fish wire providing bushes at both ends of the pipe.
19 Connect the service lines to the energy meter and then to the cut outs.

20 Connect an earth continuity conductor (GI 12 SWG) between the ‘U’ clamp of the GI pipe and to the consumer main board earth terminal.
21 Provide earth clamps on the GI pipe for earthing.
22 Connect the phase cable of the service cable to the phase wire of the distribution line through a joint or by a connector.
In some electricity boards aerial fuses are introduced between the distribution line and the service cable. Follow the procedure as per the local regulation.
23 Connect the neutral cable of the service cable to the neutral wire of the distribution line through a joint or by a connector.
Service lines should be inspected by competent authority (EB) and the aerial fuse will be provided by them only.
24 Inspect the service line connections and then energise the line.

Electrical Exercise 4.6.202
Electrician - Transmission and Distribution
Install bus-bar and bus coupler on LT line
Objectives: At the end of this exercise you shall be able to
• determine the location for installing bus bar and select the bus bar with bus coupler
• mount and fix the bus bar
• insert the plug -in-boxes in the bus bar system and also bus coupler
• test for earth continuity of bus bar and for insulation resistance.
Requirements
Tools/Instruments
• Electrician tool kit - 1 No.
• DE spanner set (6 mm to 25 mm) - 1 Set
• Crimping tool - 1 Set
• Ladder with adjustable height - 1 No.
• High stool - 1 No.
• Hand hacksaw frame 300 mm - 1 No.
• Megger 500V - 1 No.
Materials
• Busbar of available current rating and standard length / current rating - 2 Nos.
• Plug - in boxes 32A - 2 Nos.
• Busbar brackets, M.S flat, for suspending - as reqd. the bus bar or GI pipe for supports and all supporting accessories
• Nut and bolts size andPROCEDURE
1 Trace the workshop layout and calculate the total

electrical capacity of machines, main power supply entry point and determine the rating.
2 Determine the busbar layout and the required length of the busbar.
3 Determine from the site what type of support is required to lay the busbar.
4 Mount and fix the busbars to the supporting structure. (Fig 1 and Fig 2).
5 Insert the plug - in-boxes in to the plug -in-points. (Fig 1)
6 Couple the new busbar mechanically and electrically by using bus coupler, if another length is needed. (Fig 3)

If any over lapping ends of the busbar join by bolting together.
7 Secure busbar with screws locking plates.
A connector - assembly which is commercially available comprises of
- rubber locating ring,
- busbar insulating tube
If connector insulating tube in knocked out condition. While coupling, make sure that the connector - assembly is properly secured.
7 Terminate the plug in boxes to the loads through metal conduit runs and suitable cables.
8 Test the bus bar system for earth continuity.
9 Test the system for continuity and insulations.
10 Connect the busbar to the incoming supply cable through trifurcating box. After ascertaining test results are OK. (Fig 3)

Electrician - Circuit Breakers and Relays
Identify various parts of relay and ascertain the operation
Objectives: At the end of this exercise you shall be able to
• identify the external controls and parts of a electromagnetic relay
• identify the external parts of the single pole over current relay.
Requirements
Tools/Equipment
• Trainees tool kit - 1 No.
1 Locate the relay parts provided in front of the relay (Fig 1) and identify the parts and fill in Table 1.
2 Note down the tap setting of current ranges at Table 2.
3 Note down in Table 2 the Indication displayed in the

dial, multiplier along with percentage of fault current
tripping time.
4 Locate the tripping. Flag indicator resetting level provided
in front panel.
Once the relay tripped the flag will indicate a
red line once it is tripped needs manual resetting
by operating the lever.
PROCEDURE
TASK 1 : Identify external controls and parts of a electromagnetic relay
• Single pole over current/earth fault
relay with instruction manual - 1 No.
SINGLE POLE OVER CURRENT RELAY
ELN47203H1
Fig 1
1
5
4
2
3
Table 1
Sl.No. Part No. Name of the external part Function
1 1 Tripping flag indicator Display tripping condition
2 2
3 3
4 4
5 5
Table 2
Sl.No Current range Multiplier of fault current Time in seconds
1 Tap setting - 0.25A

TASK 2 : Identify internal parts of a single pole over current relay
Instructor has to explain how to locate the
internal parts and function of the circuit
breaker and ask the trainees to tabulate the
identified part of the available circuit breaker
in your section.
1 Remove the front cover by loosening the four knobs
provided in the corner of relay and preserve the cover
with knobs carefully. (Fig 1)
Don’t touch (or) try to operate any projected
parts inside the relay.
2 Locate the aluminium disc fitted in the bottom of the
spindle. (Fig 2)
3 Locate the Time Multiplier Setting (TMS) fitted in the
top of the spindle.
4 Check the divisions marked on the TMS disc used for

time setting.
5 Locate the spiral spring mounted on the top of spindle to bring back the disc top its original position after tripping.
6 Locate the moving contact fitted along with the spindle on the top of disc enabling tripping circuit.
7 Locate the two terminals contact points acting as a switch to trip the circuit.
Do not allow any dust or tiny particles enter inside. Dust will deposit in the pinion and effect the disc movement.
8 Close the front panel and show the findings to your instructor.
9 Note down the identified parts in Table 3.
10 Get it checked by your instructor.
Table 3
Sl.No. Part No. Name of the internal part Function

Electrical Exercise 4.7.204
Electrician - Circuit Breakers and Relays
Practice setting of pick up current and time setting multiplier for relay operation
Objectives: At the end of this exercise you shall be able to
• calculate the fault current in different percentage
• set up current in injector unit for different fault current
• set the pick up current of a 50% fault current
• set the time multiplier for time setting under various fault condition.
Requirements
Tools/Equipments
• Trainees tool kit - 1 No.
• Over current relay with manual - 1 No.
(used in previous Ex.No.4.7.203)
• Current injection unit with manual - 1 No.
PROCEDURE
TASK 1 : Identify of pickup current and tripp the relay for different fault current
1 Identify the supply voltage required for operating over current relay to its tripping coil.
2 Identify the current input terminals of relay.
3 Identify the shorting pins of NC/NO relay contacts.
The current Injector unit is required to provide different fault current levels. The fault current settings is done in tap setting provided in the relay along with percentage of fault current with time.
4 Connect the tripping coil voltage and fault current connections from current injector to relay as per the

manual instruction. Keep all the controls at zero position in current injector unit.
Some coils requires DC supply that can be taken from current injector unit.
5 Set the tap on relay for one amp. Calculate the multiplier from the dial and set the current in current injector unit. Record the values in Table 1.
Note : A sample reading is recorded in Table 1 on the tap setting at 1A; and multiplies value-2. Trip time displayed in dial an 10 seconds
Note : Select multiplier 2, so that the total fault current is 2 amp. ensure the time multiplier disc kept at position 1.
6 Note down the corresponding time displayed on the dial for multiplier 2.
The current injection unit have different makes and specifications . Energise the relay using manual supplied along with current injection unit.
7 Switch on the current injector unit ensure that relay is energised.
8 Increase slowly the current which is the input of relay to pickup.
Table 1
Sl. TMS Position Tap set Multiplier Time in seconds Total fault Pickup Actual
No. current (A) value current current trip time
1 1 0.5 2 x 0.5 =crease the current slowly, the disc of relay start to move that is the pickup current. Note down the value in Table 1.
10 Change the tap set current to some other current value and repeat the step 5 to 9.
11 Change the tap set for other value and repeat the steps 6 to 10 and record the readings.
12 Try few more tap set values and check the pickup current.
TMS position should not be changed while doing the exercise.
TASK 2 : Reduce the tripping time by setting time multiplier setting
1 Keep all the controls knobs at zero position.
2 Set the TMS disc at 0.5 position by rotating TMS disc fitted on the main spindle.
3 Repeat the steps 5 to 10 for the new TMS value of 0.5. Enter all the readings in Table 2.
Note : It may be noted that when TMS set for 0.5 the actual trip time reduced by 50% of the trip time actual in Task 1.
Table 2

Sl. No.	TMS	Position	Tap set current (A)	Multiplier value	Time in seconds	Total fault current	Pickup current	Actual trip time
1	0.5	0.5 A	2 x 0.5 = 1A	10	Sec.	1A	<1A	
2	0.5	1.0 A						
3	0.5	1.5 A						
4	0.5	2 A						

Electrical Exercise 4.7.205

Electrician - Circuit Breakers and Relays

Identify the parts of circuit breaker, check its operation

Objectives: At the end of this exercise you shall be able to

- identify the external parts of air circuit breaker
- identify the internal parts of air circuit breaker
- test the manual tripping of air circuit breaker.

Requirements

Tools/Equipments

- Trainees tool kit - 1 No.
- Multimeter/ohm meter - 1 No.

PROCEDURE

TASK 1 : Identify the external parts and control switches of air circuit breaker

1 Verify the specifications of air circuit breaker with instructions manual. (Fig 1)

Different makes of circuit breakers are available in the market. The air circuit breaker mentioned here is only a sample model for your guidance.

The instructor may arrange the available model with necessary instructions if necessary.

2 Identify the label numbers of the external part mentioned in Fig 1.

3 Write the corresponding label numbers against the corresponding external parts names only given in Table 1.

Table 1

Name of external parts

Sl.No.	Parts label no	Name of the part
1	1	
2	2	
3	3	
4	5	
5	6	
6	7	
7	9	
8	13	
9	17	

4 Get it checked with your instructor.

- Air circuit breaker 3 phase 415V

maximum capacity 400 KA with
instruction manual - 1 No.
Fig 1
AIR CIRCUIT BREAKER
ELN47205H1
TASK 2: Identify the internal parts of air circuit breaker
1 Remove the front cover carefully.
Do not remove any permanent parts of the
breaker.
2 Identify the main internal parts (Fig 2) fitted in the
breaker and note down in Table 2.
3 Locate the fixed main contact and movable main
contacts.
4 Check the continuity of the contacts.
5 Locate the tripping coil terminals.
6 Remove the arcing chamber unit and test the arc
chutes and diverters.

7 Locate the manual tripping lever to trip manually.
8 Connect the ACB to the main supply and switch ON.
9 Check the condition of indicating and tripping lamps.
10 Charge the breaker manually by operating handle.
11 Check the engaged main contact and confirm by

Project work
Objectives: The Trainees/Participants shall be able to
• select a project work of their choice
• prepare the list of materials required and collect them
• list out the tools required
• prepare a brief note on the project
• complete the project and submit the project report with all the details.
Note: Instructor has to explain in detail
regarding the project works to be carried out
in the section. The trainees may be divided
in groups according to the strength available
in section and give all details how to prepare
and finish the work with complete
workmanship and accuracy.
• Step to start and follow the project work
• Motivate the group by emphasising the technical work
involved and its future influences.
• Divide the work equally and make sure in yoke
participating with full interest.
• Start the project work, test it stage by stage and
complete it.
• Test the completed project job for its functionality and

its utility.
• Prepare a project report containing its technical parameters, specification, material requirement and its cost, operational procedure, maintenance, utility and marketing etc.
• Indicate the scope of future expansion, easy conversion to other project for advanced version in the report.
• Get it checked with your instructor.
The project should be completed with all operational with instructions necessary procedure.
Safety devices are to be placed according to the project and its functions.
Maintenance and repair instructions should be indicated clearly.
Note: Instructor has to evaluate the project work with all records and reports. Marks to be awarded for the project working, accuracy, workmanship, safety features and its work performance related to the viva questions.
Project works
1 Battery charger/Emergency light
2 Control of motor pump with tank level
3 DC voltage converter using SCRs
4 Logic control circuits using relays
5 Alarm/indicator circuits using sensors
Note :
1 Some of the sample project works (indicative only) are given against each semester.
2 Instructor may design their own project and also inputs from local industry may be taken for designing such

dentify the parts and compare with the service manual.
7 Identify and trace the tripping circuits.
8 Carefully inspect the parts for burnt smell, visible indication of burns, pittings and discolouring.
9 Interpolate your finding with the maintenance record sheet information to pin point the faulty part.
10 Identify the part number from the service manual and draw the parts from the stores.
11 Check the correctness of the part received from the stores and then replace the part in the circuit breaker.
General maintenance procedure
12 Check the mounting bolts/studs for correct tightness.
13 Check the verticality of the circuit breaker with the help of a plumb bob, and horizontality with the help of spirit level.
If necessary correct them by mounting bolts.

Table 1
Technical data of the circuit breaker
i Type of the circuit breaker .....
ii Type designation .....
iii No. of phases/poles .....
iv Rated voltage .....
v Maximum voltage .....
vi Rated frequency .....
vii Rated current .....
viii Rated symmetrical breaking capacity .....
ix Rated making current .....
x Rated short time current .....
xi Quantity of oil per pole .....
xii One minute try withstand voltage .....
xiii Impulse withstand voltage .....
xiv Type of closing device .....
xv Trip free/fixed trip .....
xvi Weight of the oil .....
xvii Quantity of oil in litres .....
xviii Nett weight of the circuit breaker with oil in kg .....
xix Overall dimensions of OCB mounted on frame .....
xx Ambient temperature for which OCB is designed .....
xxi Auxiliary voltage for shunt trip coils .....
xxii Auxiliary voltage for under-voltage release .....
xxiii Auxiliary supply voltage for motor drive .....
14 Check the stationary, fixed, arcing, intermediate and main contacts. Clean them with a steel wire brush or sandpaper grade ‘0’ to remove any deposit due to oxidation. Figs 1 and 2 are given for your guidance. If pittings are heavy, use a flat file to remove the pittings. If the surface area is re

Date of birth
Day Month Year Scottish candidate number
Total marks — 110
SECTION 1 — 20 marks
Attempt ALL questions.
SECTION 2 — 90 marks
Attempt ALL questions.
Show all working and units where appropriate.
You should refer to the National 4/5 Engineering Science Data Booklet which you have been given.
The number of significant figures expressed in a final answer should be equivalent to the least
significant data value given in the question. Answers that have two more figures or one less figure than this will be accepted.
Write your answers clearly in the spaces provided in this booklet. Additional space for answers is
provided at the end of this booklet. If you use this space you must clearly identify the question
number you are attempting.
Use blue or black ink.
Before leaving the examination room you must give this booklet to the
Invigilator; if you do not, you may lose all the marks for this paper.
A/PB
X823750102
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SECTION 1 — 20 marks
Attempt ALL questions
1. The parts of a doorbell, consisting of a button and speaker, are shown.
button speaker
(a) Complete the system diagram shown below for the doorbell by adding the
missing output.
user input doorbell
The doorbell operates without the use of feedb

rt of a circuit is shown.
120 Ω
V1
(a) Calculate the voltage V1 across the 120 Ω resistor when the current flow is
0.0025 A.
The 120 Ω resistor is replaced by one with a larger resistance.

(b) State the effect on the current if the voltage V1 remains the same.
[Turn over
2
1
2
1
X823750106
page 06MARKS DO NOT
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MARGIN
6. A drill uses a 1.5 A, 18 V rated battery.
(a) Calculate the electrical energy supplied by the battery when the drill is used for 160 seconds.
Grease is used to lubricate the gear system within the drill.
(b) Describe a reason for lubricating the gear system.
2
1
X823750107
page 07MARKS DO NOT
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MARGIN
7. A lamp in a child’s night light will automatically switch on when the room is dark.
The incomplete circuit diagram used to control the lamp is shown below.
5 V
0 V
component Y
(a) Complete this circuit diagram by adding the symbol for the lamp.
(b) State the full name of component Y in this circuit.
(c) Indicate, with a cross (X) on the circuit above, where an ammeter would be connected to measure the current flowing to the base connection of the transistor.
(d) State the name of the component that could be used to protect the transistor from a large input current.
[Turn over
1
1
1
1
X823750108
page 08DONOT
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THIS
M
ARGIN
SECTION 2 — 90 marks
Attempt ALL questions
8. A car safety system detects when the driver’s seatbelt is unfastened.
clip and seatbelt sensor
seatbelt strap
The safety system is operated by a microcontroller.
Input and output connections to the microcontroller are shown in the table below.

Input connections Pin Output connections
7 warning lamp
6 buzzer
seatbelt sensor 0
The safety system operates using the following sequence:
• A warning lamp and a buzzer turn off.
• When the seatbelt sensor is on, the sequence will return to the start.
• If the seatbelt sensor is off, the warning lamp will turn on.
• The buzzer will then turn on and off three times over a total period of
1.8 seconds.
• The sequence will return to check the seatbelt sensor aga

Complete the flowchart for the sequence shown opposite, with reference to the Data Booklet and input/output connections.
Include all pin numbers and delay units in your flowchart.
start
pin 6 off
pin 7 off
Yes
No
10
[Turn over
X823750110
page 10MARKS DO NOT
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MARGIN
8. (continued)
A force applied to the seatbelt strap results in a stress of 15 N mm−2. The seatbelt strap has a cross-sectional area of 48 mm2.
(b) Calculate the force applied. 3
X823750111
page 11
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X823750112
page 12DONOT
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THIS
M
ARGIN
9. A pneumatic circuit is used to arrange bottles ready for packaging in a production line.
The pneumatic circuit used to arrange the bottles is shown below.
cylinder A
cylinder B
2
1
4
5
3
signal from
microcontroller

X823750113
page 13MARKS DO NOT
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MARGIN
9. (continued)
(a) Describe the operation of the circuit shown opposite.
When a signal is received from the microcontr ir at a pressure of 0.32 N mm−2 is supplied to cylinder B . This results in an
outstroking force of 620 N.
(b) (i) Calculate the area of the piston.
(ii) Calculate the diameter of the piston.
3
3

X823750115
page 15MARKS DO NOT
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9. (continued)
A microcontroller based system is used to detect the bottles.
The program used to count six bottles is shown below.
line program
1 main: let count = 0
2 check: if input2 is off then check
3 let count = count + 1
4 if count = 6 then label_1
5 goto check
6 label_1: switch on 7
7 pause 500
8 switch off 7
9 goto main
(c) State the line number that contains a time delay.
An incomplete diagram for the microcontroller based system is shown below.
(d) Complete, with reference to the program above, the wiring of the bottle sensor and the transistor to the microcontroller.
3
2
1
0
4
5
6
7
bottle
sensor
5 V
0 V
12 V
signal to
pneumatic
circuit

[Turn over
1
2
X823750116
page 16
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X823750118
page 18MARKS DO NOT
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MARGIN
10. (continued)
Part of the circuit used in the warning sign is shown below.
390 Ω 82 Ω
78 Ω
86 Ω
(d) (i) Calculate the resistance of the three LEDs in parallel. The warning sign is rated at 12 V, 1.8 W.
(e) Calculate the current supplied to the warning sign.
[Turn over
3

X823750120
page 20MARKS DO NOT
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MARGIN
11. The mountain coaster shown below allows riders to travel downhill in an unpowered carriage. The rider can control the speed of the carriage by using a braking system.
support
structure
carriage
track
wheelsbrake lever
A number of different engineers were involved during the development and construction of the mountain coaster.
(a) (i) Describe a task that a mechanical engineer would carry out during the development of the carriage.
(ii) Describe a task that a civil engineer would carry out during the development of the mountain coaster.
(iii) Describe a task that an environmental engineer would carry out during the construction of the track.
1
1
1
X823750121
page 21MARKS DO NOT
WRITE IN
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MARGIN
11. (continued)

At the start of the ride, 6.2 m above the ground, the carriage and rider have a combined potential energy of 13 kJ.
(b) (i) Calculate the combined mass of the carriage and rider.
(ii) Calculate the kinetic energy of the carriage and rider when released and travelling at a velocity of 2.7 m s−1.
[Turn over
3
2
X823750122
page 22MARKS DO NOT
WRITE IN
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MARGIN
11. (continued)
A structural engineer analyses the forces acting through part of the support structure for the track.
A triangle of forces diagram used in the analysis is shown below.
2500 N
2600 N
scale: 10 mm = 500 N
F
(c) Determine, with reference to the triangle of forces diagram, the size of unknown force F.
F = N
The properties of the four metals considered for the support structure are shown in the table below.

Metal	Corrosion resistant	Durability
A	no	low
B	yes	high
C	yes	low
D	no	high

(d) Select the most suitable metal (A–D) from the table above to be used for the support structure and justify your choice

Choice of metal
Justification
1
2
X823750123
page 23MARKS DO NOT
WRITE IN
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MARGIN
12. A washing machine is shown.
A sub-system diagram showing the control of the water temperature in the washing machine is shown below.
temperature
sensor
output
driver

control heating
element
actual water
temperature
system
boundary
set water
temperature
(a) Describe the reason for including a system boundary in a sub-system diagram.
(b) Describe, with reference to the sub-system diagram above, the control of the water temperature.
The water temperature is set . . .
1
3
[Turn over
X823750124
page 24MARKS DO NOT
WRITE IN
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MARGIN
12. (continued)
A thermistor is used in the temperature sensor.
The operating characteristics of six thermistors are shown on the graph below.
−75 −50 −25 0 25 50 75 100 125150 200 250 300
2
2
2
2
2
2
3
3
3
3
3
3
5
5
5
5
5
5
8
8
8
8
8
8
1
2
3
4 6
5
10
100

1k
10k
100k
1M
10M
temperature (°C)
resistance (Ω)
(c) State the thermistor number from the graph above that has a resistance of 1 kΩ when the temperature is 30 °C. 1
MARKS DO NOT WRITE IN THIS MARGIN
12. (continued)
(d) Explain why using a low temperature wash cycle can affect climate change.
The washing machine’s heating element is tested using 8.6 kg of water.
(e) Calculate the heat energy when the water temperature is raised by 15 °C.
MARKS DO NOT WRITE IN THIS MARGIN
12. (continued)
The logic diagram for part of a circuit used in the washing machine is shown.
A
B Z
D
C
(f) Complete the truth table for this logic diagram.

A	B	C	D	Z
0	0			
0	1			
1	0			
1	1			

The truth table for another logic circuit in the washing machine is shown below.

F	G	H	Y
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	0

(g) Complete the Boolean equation for output Y in terms of inputs F, G and H

X823750128
page 28MARKS DO NOT
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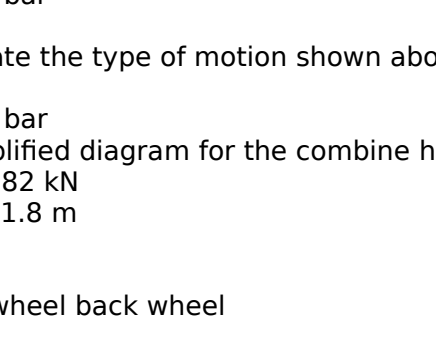
MARGIN
13. A combine harvester used to gather crops is shown below.


(a) State the type of motion shown above at the:
reel
cutter bar
A simplified diagram for the combine harvester is shown.

2
X823750129
page 29MARKS DO NOT
WRITE IN
THIS
MARGIN
13. (continued)
(b) (i) Calculate the reaction force RA by taking moments about RB.
(ii) Calculate the reaction force RB.
[Turn over
3
2
X823750130
page 30MARKS DO NOT
WRITE IN
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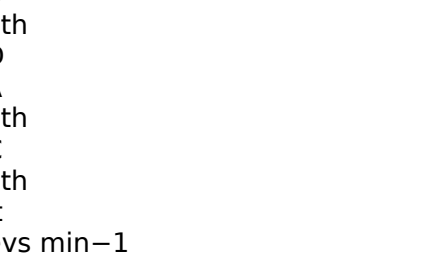
MARGIN
13. (continued)
Part of a drive mechanism used in the combine harvester is shown.


(c) Calculate the number of teeth on gear D. 4
X823750131
page 31MARKS DO NOT
WRITE IN
THIS
MARGIN
13. (continued)
The combine harvester uses a Global Positioning System (GPS) when cutting the

crop. This is an established technology.
An emerging technology is one that is new and still to be tried commercially within a product or system.
(d) Explain a possible impact of an emerging technology which you are familiar with.
Emerging technology
Impact
[Turn over
2
X823750132
page 32MARKS DO NOT WRITE IN THIS MARGIN
14. A laminator is used to cover a sheet of paper in a plastic sleeve.
The plastic sleeve is heated by the laminator as it passes through.
The circuit used to indicate when the laminator is at the correct temperature is shown below.
green
Vin
red
input sub-system +V
−t°
0 V
Vs
(a) Describe the operation of the input sub-system as the temperature increases.
Make reference to the resistance of the thermistor and the voltage V As the temperature increases . . .
2

X823750133
page 33MARKS DO NOT WRITE IN THIS MARGIN
14. (continued)
The input sub-system is shown below.
−t°
0 V
5.0 V
1.9 V1.7 kΩ
(b) Calculate the resistance of the thermistor for the condition shown above.
(c) Describe, with reference to the circuit shown opposite, the effect on the red LED and the green LED when the transistor first activates the relay.
When the transistor activates the relay . . .
4
2
[Turn over
X823750134
page 34MARKS DO NOT WRITE IN THIS

MARGIN
14. (continued)
A possible modification to the circuit is to include an audible alert when the laminator is at the correct temperature.
(d) Draw, in the circuit below, the symbol for a buzzer connected in parallel with the green LED.
green
red
+V
2
X823750135
page 35MARKS DO NOT
WRITE IN
THIS
MARGIN
14. (continued)
An electronic engineer used computer simulation to test the modified circuit.
(e) Describe an advantage of using computer simulation compared to building a circuit for testing purposes.
A large reduction in speed is required for a feed roller to slowly move the plastic sleeve and paper through the laminator.
(f) Explain why a compound gear train is more suitable than a simple gear train to create this large reduction in speed in the laminator.
[END OF QUESTION PAPER]
1
2
X823750136
page 36MARKS DO NOT
WRITE IN
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MARGIN
ADDITIONAL SPACE FOR ANSWERS
X823750137
page 37MARKS DO NOT
WRITE IN
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ADDITIONAL SPACE FOR ANSWERS
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National
Qualifications
2019
2019 Engineering Science
National 5
Finalised Marking Instructions

General marking principles for National 5 Engineering Science
Always apply these general principles. Use them in conjunction with the detailed marking instructions,
which identify the key features required in candidates' responses.
(a) Always use positive marking. This means candidates accumulate marks for the demonstration
of relevant skills, knowledge and understanding; marks are not deducted for errors or omissions.
(b) Where a candidate makes an error at an early stage in a multi-stage calculation, credit should
normally be given for correct follow-on working in subsequent stages, unless the error significantly reduces the complexity of the remaining stages. The same principle should be applied in questions which require several stages of nonmathematical reasoning.
(c) All units of measurement will be presented in a consistent way, using negative indices where
required (eg ms-1). Candidates may respond using this format, or solidus format (m/s) or words
(metres per second), or any combination of these (eg metres/second).

Marking instructions for each question
Section 1

Question	Expected response	Max mark	Additional guidance
1. (a)		2	1 mark for electrical as input. 1 mark for heat as output. Do not accept electricity/electric.

(b) Closed loop (control) 1 Do not accept closed on its own.
(c) 1 1 mark for correct symbol.
-t◦ not required.
Small line must be parallel to long
side of resistor.
Do not accept an arrow on any end.
2.E
P t
=6750
270
P =
P = 25
P = 25 W (2 sf)
2
1 mark for substitution.
1 mark for correct answer from
given working with unit.
3. (a) Air that operates a piston/cylinder. 1 Descriptive response of function.
Accept instroke/outstroke/actuate a
cylinder.
Must specifically refer to operating
(stated or inferred) a cylinder/
piston.
(b) Air used to actuate a valve. 1 Descriptive response of function.
Must specifically refer to operating
(stated or inferred) a valve.

Question Expected response Max
mark Additional guidance
4. (a)Speed of Input
Velocity Ratio Speed of Output
=800
Velocity Ratio 320
=
Velocity Ratio = 5 : 2
2
1 mark for substitution.
1 mark for correct answer from
given working.
Accept 2•5 : 1 or 2•5
Ignore any units.
(b) Anti-clockwise. 1 Do not accept other way or opposite
way.
Accept indication of direction on
diagram.
5. (a) (i) Civil. 1
(ii) Environmental. 1
(b) Less stressful journeys .
Journey time quicker.
City roads less congested.
Areas bypassed will be
quieter/safer.
City will be less polluted to live in.
Jobs created in the construction of
the bypass/of housing in outlying

areas.
2 1 mark for each descriptive response of positive social impact of a city bypass.
Assume impact refers to bypass unless indicated in response.
Do not accept quick on its own.
Do not accept less congestion on bypass.
6. 3 1 mark for NOT gate wired to input B.
1 mark for OR gate wired to A and (NOT) B.
1 mark for AND gate wired to input C and A (OR) B.
No FTE from gate.
page 08
Question Expected response Max mark Additional guidance
9. (a) 1 Dashed box around process.
(b) The pre-set position is selected...
The control unit compares the pre-set position with the actual position.
The bed/motor will start to move (if it is not in the desired position).
When the desired position is detected the motor will stop.
3
1 mark for comparison by control unit of positional sensor signal to pre-set value.
1 mark for motor starting.
1 mark for motor stopping in relation to desired position.
(c) When an appropriate input signal is applied to the base an output current will flow at the collector/emitter.
2 1 mark for input signal at base (cause). Accept voltage as signal.
1 mark for output current at collector/emitter based on given cause (effect).
(d) Z = (A•B) + (A•B) 3 1 mark (A•B) with brackets.
1 mark (A•B) with brackets.
1 mark for OR-ing all statements.
If just a single statement is given then bracket not required.
accept alternatives such as
Z = A + B
Z = (A+B) + (A•B)
(e) G H Y
0 1 1
0 1 1
0 1 1

0 1 1
0 1 1
0 1 1
1 0 0
1 0 1
3
1 mark per correct complete column.
Allow for follow through error.
Column H = NOT G..
Column Y = F OR.

Question Expected response Max mark Additional guidance
10. (a) Saw blade: rotary.
Pneumatic piston: reciprocating.
2 1 mark for saw blade motion.
1 mark for piston motion.
Accept rotational/reciprocal.
Do not accept rotating.
(b) When an increase in pressure is detected by valve 3...
...and when valve 1 is actuated (air is sent actuating valve 4), causing the piston to instroke...
valve 7 is actuated then there is a time delay...
...then valve 4 actuates causing the piston to outstroke.
3
1 mark for AND control with valve 1 and 3 causing the piston to instroke.
1 mark for time delay after valve 7 being actuated.
1 mark piston outstroke after valve 4 actuated and valve 7/time delay.
(c) 1 X on lower pipe to double acting cylinder.
Accept X on the bottom exhaust port of the 5/2 valve.
(d) The control of the piston movement could be easily changed/updated.
The piston time delay could be easily changed/shortened.
The piston time delay could be more consistent/accurate.
1 Descriptive response relating to advantage of microcontroller control of piston movement.
Do not accept fewer components or cost savings.

Question Expected response Max mark Additional guidance
10. (e) (i)2

d
Apiston 4
π
=· ×
= =
2
3 14 88
Apiston 6079
4
(mm2)2
d
Arod 4
π
=· ×
= = ·
2
3 14 24
Arod 452 2
4
(mm2)
Aeffective = Apiston – Arod
Aeffective = 6079 – 452•2
Aeffective = 5627
Aeffective = 5600 mm2 (2 sf)
3
1 mark for area of rod (unit not required).
1 mark for area of piston (unit not required).
1 mark for correct subtraction answer with unit.
Using the π function will give different intermediary values (6082 and 452•4) but same final answer to 2 sf.
(ii)F
P A
=F
0 20 5600
· =
F = 0•20 x 5600
F = 1120
F = 1•1 kN (2 sf)
3
1 mark for substitution
Allow FTE from part (e)(i).
1 mark for transposition.
1 mark for correct answer from given working with unit.

Question Expected response Max mark Additional guidance
11. (a) (i) ∑CWM = ∑ACWM
(RA x 2•4) = (680 x 0•4) + (930 x 3•6)A
3620
R 2 4
= ·

RA = 1508
RA = 1•5 kN (2 sf)
3
1 mark for substitution.
1 mark for transposition.
1 mark for correct answer from
given working with unit.
(ii) ∑Fvertical = 0
930 + 680 = 1500 + RB
RB = 1610 – 1500
RB = 110
RB = 110 N (2 sf)
2
1 mark for substitution
Allow FTE from part a(i).
1 mark for correct answer from
given working with unit.
If moments used to determine RB
then accepted 101•7 N .
(b) Equilibrium. 1 Ignore additional description
(c)F
A
= σ2500
0 06 A
· =2500
0 06
A = ·
A = 41670
A = 42000 mm2 (2 sf)
3
1 mark for substitution..
1 mark for transposition.
1 mark for correct answer from
given working with unit.
(d) Design how to connect the visitor
centre to the national grid.
Calculate the electrical power
requirements of the visitor centre.
Select appropriately rated cables.
Calculate the lighting requirements/
plan the lighting layout.
2 1 mark for any appropriate
descriptive response of an engineer's
task
(design/calculate/select/model...)
and the electrical aspect (must be
linked to design of visitor centre).
Not design a circuit/wiring on its
own.
Not electronic or electrician related.